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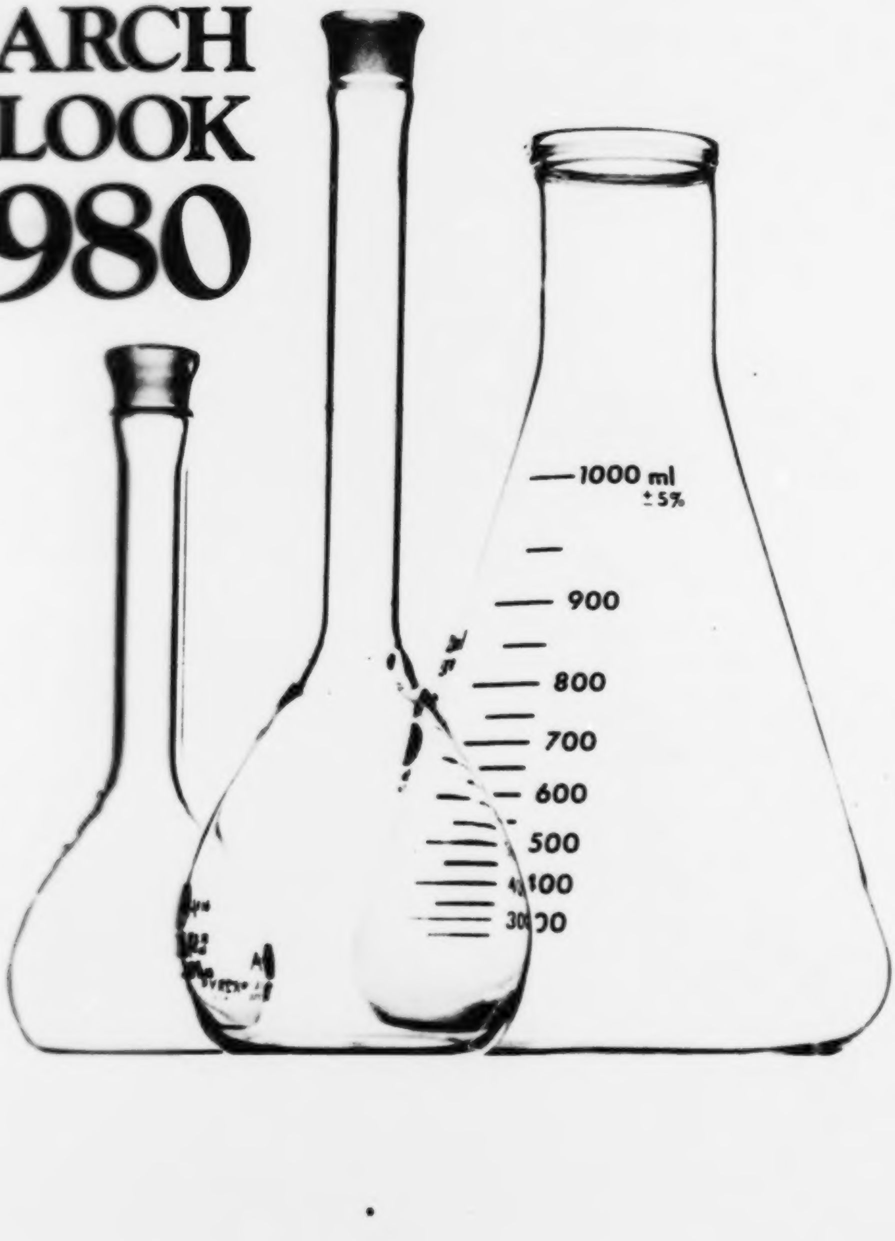
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FOREWORD

Research Outlook 1980 marks another milestone in the progression begun in 1978 to present a balanced five year environmental research plan, aimed at satisfying short-term regulatory requirements and at anticipating future problems. This progress will continue in the future.

The new research planning system initiated last year is in place and is working well. We are continuing to enhance the dialogue established by the research committee system between regulatory, regional and research planners. These committees will play an even greater role in preparing future **Outlooks,** as the multiyear strategies developed by the committees become the key building blocks of the plan. The **Research Outlook** will also be used increasingly in our planning process as a guide to future research needs; the **Outlook** will therefore both shape and be reshaped by the strategies.

Once again I want to invite your comments on the report. It is through constructive comment and the fresh perspective provided by the Science Advisory Board, the Congress, the scientific community and the public that we continue to improve our plans for environmental research.

Stephen J. Gage

Stephen J. Gage
Assistant Administrator
for Research and Development

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This report is submitted to Congress annually to present EPA's 5-year plan for environmental research. The report focuses on such areas as Toxic Substances, Air, Water Quality, Wastewaters and Spills, Drinking Water, Solid and Hazardous Wastes, Pesticides, Non-ionizing, Radiation, Noise, and Energy.

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	Research Projected Research	

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This report is submitted pursuant to section 5 of Public Law 94-475, 90 Stat 2071, which requires the annual submittal to Congress of a 5-year plan for environmental research.

INTRODUCTION

Research Outlook 1980 is the fifth in a series of EPA annual reports mandated by Congress. The scope and content of the report series has continually broadened and now includes a focus on future research and emerging problems. While the first two **Outlooks** described EPA's then existing research program, the third, **Research Outlook 1978,** identified the philosophies that guide our research and the environmental issues that were and, in some cases, still are, developing. In contrast, **Research Outlook 1979** addressed research needed to best deal with environmental problems and stressed plans to meet those needs. **Research Outlook 1980** maintains the progress to effectively portray EPA's research plans by describing refinements and extensions to the plans and by tying the plans closely to the regulatory needs of EPA. The report also outlines the emerging problems we have identified and summarizes dynamic approaches to deal with them.

EPA's Office of Research and Development (ORD) has steadily improved research planning and management to support these regulatory programs. This work for the past year culminated in the establishment and initial operation of thirteen Research Committees to better define and formulate future EPA research. This significant change in the planning process will result in materially improved research programs. The **Research Outlook** series will be a part of the improvement and, as such, will gain prominence in the research planning process. Thus, one major objective this year was to integrate **Outlook** into the new planning process and to increase the use of **Outlook** within EPA as a guide to future research needs and emerging environmental problems.

Research Outlook 1980 describes EPA's research plan for ten interrelated programs; each program is discussed in a separate chapter. The chapters are presented in the order in which our budget is submitted to Congress with two exceptions: "Toxic Substances" is the first chapter to reflect the importance we attach to the toxics program and "Anticipating Environmental Problems" closes the report to leave us with a look to the future. The chapters include discussions of environmental concerns, approaches to abate pollution and the research plan to support the approaches. Milestones such as major products or primary program events provide a representative picture of our plans for fiscal years 1980 through 1984. These milestones are identified in the research plans at the end of each chapter by a number/letter designation (e.g., A1, A2, or C6 or G8); they are also keyed into the text for easy reference.

The report provides insight into the efforts to refine and institutionalize the research planning changes. Research options based on budget projections for a no growth, moderate growth (5%) and high growth (10%) scenario are presented in an attempt to provide an understanding of major emphases and tradeoffs as defined by the Research Committees. The relationship of chapter to specific Research Committee is:

CHAPTER	RELEVANT RESEARCH COMMITTEES
Toxic Substances	**Chemical Testing and Assessment**
Air	**Gaseous and Inhalable Particulate Pollutants** **Hazardous Air Pollutants** **Oxidants** **Mobile Source Air Pollution**
Water Quality	**Water Quality**
Industrial and Municipal Wastewaters	**Industrial Wastewaters** **Municipal Wastewaters and Spill Prevention**
Drinking Water	**Drinking Water**
Solid and Hazardous Waste	**Solid Waste**
Pesticides	**Pesticides**
Non-Ionizing Radiation	**Radiation**
Noise	—
Energy	**Energy and nine Committees**
Anticipating Environmental Problems	**Of interest to all Committees**
Research Options	**All Committees**

Priorities

EPA has been given the lead responsibility for identifying, evaluating and controlling environmental pollutants.

Broadly stated, EPA's overall priorities are to:

- Reduce public exposure to dangerous pollutants;
- Protect sensitive ecological systems; and
- Improve management of our environmental regulatory programs.

To support EPA's priorities, our research first addresses those pollutants which present the greatest health risk. Over the last several years, we have increasingly focused on dealing with pollutants as they affect human health, although we also strive to protect the environment by studying particularly sensitive environmental systems such as wetlands. The research programs are also beginning to take a multimedia approach to environmental protection through evaluation and integration of environmental problems at every point in the life of a pollutant—production, transport, use, discharge or disposal.

The EPA priorities and relevant research priorities undergo a vigorous annual review in conjunction with the zero base budgeting process. A look at EPA's research budget for the last two years and proposed for FY 81 shows that research budget increases have been less than overall Agency budget increases. This difference is due chiefly to the Agency's greater emphasis on regulatory and enforcement activities.

Another trend that reflects changing priorities is an increase in resources for toxics research. From a modest program in FY 79 with resources of almost $15 million, the Toxics Research Program in FY 80 was funded at just under $27 million. Toxics health effects research received the most resources by far, spurred by the Public Health Initiative that was sponsored in FY 80 and will be sustained in FY 81. In concert with the Agency's priorities, the program to determine ecological effects of toxics has also increased substantially.

Similarly, the budget of the Solid and Hazardous Waste Research Program, also once modest, has begun to rise dramatically in response to increased awareness of problems associated with hazardous waste disposal. This upward trend will most likely continue until problems raised by the Love Canal incident and other abandoned waste disposal sites are solved.

In contrast to the above programs, the Water Quality Research Program, which traditionally had a large budget, has consistently experienced budget decreases over the last several years. Moreover, the focus of the program has shifted from research on the more traditional pollutants to toxic substances. The majority of the budget decrease has been in water control technology research.

Finally, an increasing EPA priority is the integration of all environmental programs. This integration is essential because legislation to control pollution now covers all environmental media—air, water and land. Previous air and water legislation had inherent gaps in the waste disposal cycle by not providing for control of the disposal of pollutants in or on land. The Resource Conservation and Recovery Act (RCRA) closes those gaps and makes sure there is no "free dumping ground." This multi-media control requires an integrated approach to optimize the mix of environmental controls which will minimize the adverse effects of pollution. Some integration can be seen in the efforts to consolidate our grant and permit programs; integration of

	ORD ($M)	AGENCY ($M)	ORD % OF AGENCY BUDGET
FY 79	324.5	1,175.4	27.6
FY 80	333.3	1,260.2	26.5
FY 81	368.7	1,391.3	26.5

water quality, drinking water, solid waste, hazardous wastes and underground injection programs will serve as examples for other areas. Our research programs support these efforts.

Two prime examples of programs now integrated are our research efforts in sewage and industrial sludge disposal and our program investigating acid rain. Sewage and sludges, which can contain contaminants adverse to human health and the environment, can be dealt with through sound management practices. Our research, therefore, will develop better sludge treatment and disposal techniques, such as the use of municipal sludge as a soil amendment or fertilizer, and will develop sophisticated technologies to help reduce future increases in sludge from entering our air and water. The acid rain research program will consist of monitoring and study of the environmental effects and atmospheric processes germane to the problem. The multi-media nature of the acid rain problem is reflected by the fact that it is discussed in a number of chapters of this **Research Outlook** (i.e., Air, Water Quality, Energy, Anticipatory and Global Issues).

Chapter Summaries

Presented below are brief summaries of the chapters of this report. These overviews serve two purposes: first, they highlight the key planned outputs of each research program for readers who need not know the details of EPA's research programs; and second, they can illustrate the commonalities and differences between the programs.

Toxic Substances. Our toxics research program is designed to meet the responsibilities mandated by the Toxic Substances Control Act of 1976; it is also designed to provide information to our other programs about the character and means to control toxic substances. The structure that has evolved to fulfill these dual aspects of our program is: research into the effects of toxics, identification of the receiving environmental media and related effects, characterization of the types of toxic pollution and determination of the sources of toxicants.

Reflecting this structure are our four research study areas: (1) health effects—to concentrate on the delayed or cumulative effects of toxicants on humans; (2) environmental effects—to investigate the ecological effects and chemical fate of compounds in the environment; (3) monitoring support — to develop and refine the methods to measure and monitor toxicants and to assure the quality of pollution samples and data; and (4) industrial processes — to identify toxicants from generic industrial processes common to broad classes of industries.

Air. Our air pollution research program continues to provide research to help abate pollution and support Air Quality Standards.

The six areas of study are: (1) criteria pollutants—to identify and quantify human health effects of air pollution exposures as determined through animal models, clinical studies and epidemiological studies; the resulting information will provide a base for review of the National Ambient Air Quality Standards; (2) hazardous pollutants — to provide information for the identification and control of potential atmospheric carcinogens, and to study chronic effects from noncarcinogenic pollutants; (3) long range transport and transformation—to shift our perspective from local to regional-scale phenomenon and problems and to predict reductions of regional effects through applications of control technologies; (4) particles—to characterize atmospheric particles including their sources and to determine the health, ecological and visibility effects and means for control; (5) vehicles—to assess health effects pertaining to diesel emissions; (6) global—to understand the large-scale and long-term effects of air pollution on the biosphere.

Water Quality. Our water quality research program will provide the assessment methods and information necessary to assist federal, state and local governments in identifying optional water quality goals and cost-effective strategies for achieving those goals. Emphasis of our research will be on the human and ecological effects of potentially toxic chemicals that either exist in our waters and sediments now or that may be released into them in the future. The research areas of study are: (1) pollution sources—to identify and characterize sources and receiving waters and to develop new measurement techniques; (2) environmental fate — to determine the persistence, distribution, and transport of discharged pollutants; (3) human health and environmental effects — to determine the effects of exposure to toxicants in water; and (4) cost-effectiveness of management techniques especially for non point sources — to define and quantify pollution abatement costs including energy costs and to evaluate the effectiveness of control methods.

Wastewaters and Spills. The wastewater and spills research covers industrial wastewaters, municipal wastewaters, and emergency spills. The industrial wastewater research program has three major study areas: (1) industrial source characterization and assessment — to detect, identify and predict industrial pollutant impacts on water as well as cross-media impacts on land and air; (2) control methods evaluation, research, development and demonstration — to define the degree to which pollutants can be treated and to optimize and improve existing and innovative or nontreatment technologies; (3) recycle/reuse — to develop and evaluate recycle/reuse technologies for specific industrial processes.

The municipal wastewater research program is divided into nine areas of study: (1) developing and evaluating treatment processes; (2) land treatment and aquaculture; (3) sludge processing, use, and disposal; (4) toxics control; (5) improving the operation and reliability of publicly-owned treatment works (POTWs); (6) helping small communities choose treatment and disposal alternatives; (7) controlling pollution from urban runoff; (8) using treated water; (9) innovative and alternative technology.

The emergency spills research program is designed to assist industry and governments by developing technology and procedures for dealing with spills. The program also studies the fate and effects of spills and the restoration of the spills environment.

Drinking Water. Our drinking water research program is designed to provide information that will enhance the scientific and technical foundations underlying national drinking water regulations and regulations to protect groundwater quality. The research will identify drinking water contaminants and their distribution in water supplies, define the contamination effects on human health, establish analytical procedures to monitor contaminants and describe beneficial changes in treatment processes or technologies for organics, inorganics and microbial contaminants. In addition the program will gather baseline information on groundwater contaminants. This will assist in ranking the seriousness of potential contamination sources.

Solid and Hazardous Wastes. The solid and hazardous wastes research program supports EPA's stepped approach to solid wastes management including both the short-range and the long-range priorities developed in response to the Resource Conservation and Recovery Act. The number one priority of the Act is the concern for public health and safety; this concern is also EPA's chief goal for implementation of the Act's programs. Our research in support of the Act is divided into four study areas: (1) identification, assessment, quality assurance and technical assistance in support of EPA efforts to promulgate and enforce the hazardous waste regulations; (2) development and testing of technologies to treat and contain hazardous waste in order to minimize or eliminate their hazards; (3) assessment of the risks associated with hazardous waste and the monitoring of the transport and fate of this waste; (4) development of a balanced program to manage non-hazardous waste and high-volume waste.

Pesticides. The pesticides research plan is designed to support EPA requirements specified by the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) as amended, and the amendments to the Federal Food, Drug, and Cosmetic Act (FFDCA). The research study areas for the support of the requirements are: (1) protect public health and the environment — to identify populations-at-risk, assess population exposures, and determine adverse effects to health and ecology; (2) minimize introduction of pesticides into the environment—to develop data to support strategies that will decrease future pesticide dispersion.

Nonionizing Radiation. Our research program that supports environmental radio frequency radiation guidance will develop assessments of the health risks posed by continuous low-level exposure to such radiation. The three major study areas are: (1) biological effects—to demonstrate the existence of reproducible biological effects and to establish dose-response models; (2) mechanisms of interaction — to determine the manner in which nonionizing radiation interacts biophysically and biochemically with living systems; (3) human studies — to carry out epidemiological and clinical studies to determine the effects of radio frequency radiation exposure in human populations.

Noise. The noise research, being managed by the Office of Air, Noise, and Radiation, is designed to support the responsibilities set forth in the Noise Control Act of 1972, as amended by the Quiet Communities Act of 1978. There are three specific research study areas: (1) improve existing data—to increase the health and welfare noise data base, refine existing criteria and quantify nonauditory dose/response criteria; (2) health effects—to thoroughly understand the health implications of noise and to assure the benefits of noise control actions; (3) noise control—to develop means to control noise including transportation-related noise, machinery noise, and home interior noise.

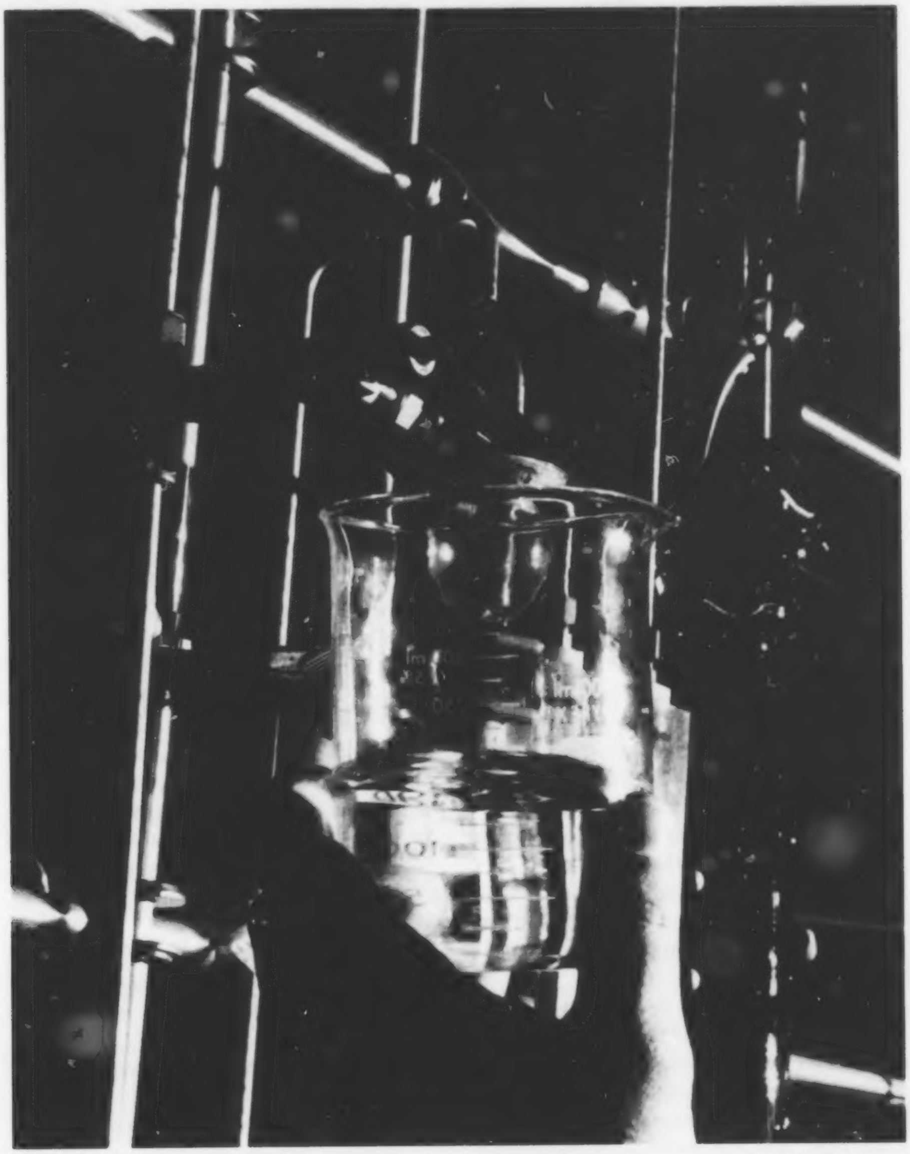
Energy. The energy and environment research program is an interagency effort to provide the information necessary to strike a balance between ample domestic energy production, reasonable cost, and environmental quality. The program is divided into a health and environmental effects program and a pollution control technology program.

The health and environmental effects program is designed to study consequences of energy extraction, processing, combustion, and disposal of residual materials. Effects will be studied for energy-related air pollution and leachate hazards; advanced fuels and advanced fuels combustion processes effects will also be studied as will offshore drilling. Effects studies will include mine reclamation, pollutant deposition on ecosystems and effects of energy-related toxicants. Atmospheric transport and effects research projects include: (1) transport and dispersion of power plant stack plumes at short range, (2) transport, transformation and dispersion of energy pollutants at long range, (3) acid deposition, (4) visibility impairing haze, and (5) synfuel atmospheric pollution.

The control technology program is divided into three study areas: (1) solid fuel extraction — to develop and demonstrate methods to control, treat and abate pollutants from mining and beneficiation, especially surface mining in the western United States; (2) conventional combustion — to develop and demonstrate cost-effective control technology to be used in conjunction with utility and industrial processes, especially technology to control sulfur oxides, nitrogen oxides, and particulates; (3) fuel conversion for synthetic fuels—to evaluate control technology for the major process streams of synfuel processes, in particular coal liquefaction and gasification and oil shale processes.

Anticipating Environmental Problems. Our anticipatory program is designed to support EPA's regulatory activities and to look over the horizon to identify trends affecting the future environment. The goal is to identify the specific types of changes that will affect the future environment, then identify and classify problems that may result from these changes. This information will assure that proper exploratory research can be instituted. Environmental problems fall into five classes: (1) known problems of known scope; (2) known problems of unknown scope; (3) potential problems contingent on technological, economic, or other discontinuities or changes in trends; (4) unknown problems which are potentially discernible; and (5) unknown problems not likely to be discernible. The mainstream of Agency research and regulations focuses on the environmental problems of the first class, where the effort involves precise quantification of problem and scope and appropriate regulatory response. The area of greatest interest for the anticipatory research program, however, are the middle three classes where we can bring light to poorly understood problems, identify the lead indicators of changing trends and uncover altogether new and pressing environmental issues.

ENVIRONMENTAL RESEARCH PLANNING AND MANAGEMENT



The planning and management of research must be dynamic. EPA's research plan supports regulations and anticipates problems.

Over the past two years, EPA has instituted major changes in the planning and management of research to support its regulatory programs. These changes are intended to better integrate the Office of Research and Development into the mainstream of the Agency's activities and thereby enhance the responsiveness of the research program to EPA's regulatory and enforcement needs.

Responsiveness Through Joint Planning

The Research Committee System. The key feature of the Agency's new joint research planning process is the establishment of the Research Committee System. The system is an outgrowth of a pilot project, initiated in 1977, that investigated the feasibility of planning ORD research programs by committees composed of representatives from ORD, the regulatory program offices, EPA Regional Offices, the Office of Enforcement and the Office of Planning and Management.

Major goals of the pilot project were to develop research plans and multi-year strategies which are closely attuned to the research needs of the Agency and to forge a link between EPA's research and development activities and the program offices responsible for developing regulations. Initially, five committees were formed to address: pesticides, mobile source air pollution, particulate air pollution, drinking water, and industrial wastewater.

The success of the pilot effort led the Agency in 1979 to increase the number of committees from five to twelve. Four of the original five pilot committees have been retained; the fifth, the Particulate Air Pollution Committee, has been expanded to encompass gaseous, as well as particulate, pollutants. The seven additional committees address oxidants, hazardous air pollutants, radiation, municipal wastewater, water quality, solid waste, and toxics testing and assessment.

Recently, ORD established a thirteenth Research Committee that will deal with energy. The nature of the energy program is such that it, in part, is complementary to established program areas; nevertheless, it also maintains a strong multi-media perspective and reflects an important interagency partnership. In areas where the energy and non-energy programs are complementary, ORD has aligned the energy program with the established committees. However, the Energy Research Committee devotes special attention to the multimedia and interagency aspects of the energy program. The new group is also responsible for a multi-year research strategy for the entire energy program. They are also responsible for maintaining close coordination with the other committees, especially during the planning process which produces ORD's program plans for each fiscal year. As the Energy Research Committee becomes fully operational in the coming months, about 93% of ORD's total program will be planned within its framework.

Each of the thirteen committees is specifically oriented to users of research information and thus is aligned to a major regulatory subject area which, in turn, corresponds to the organization and mission of a particular regulatory program office. To strengthen the research/regulatory bond, each committee is co-chaired by a senior manager from ORD and a senior manager from the committee's corresponding regulatory program office. Membership and active participation on the committees has also been sought from EPA's Regional Offices, Office of Enforcement, and Office of Planning and Management.

The responsibilities of the Research Committees are to:

- Review the upcoming year's (e.g., FY 81) research plans and formulate appropriate recommendations to improve them;
- Participate in the development of budget year plans (FY 82);
- Review the quality of ongoing and recently completed research (e.g., FY 80);
- Develop a multi-year research strategy with sufficient detail for use as a primary planning document in subsequent years (e.g., FY 83, 84, etc.).

It is that last responsibility—development of a research strategy—which is the focal point of each committee's deliberations. These research strategies are revised annually and provide the basis for preparing annual budget and other planning documents.

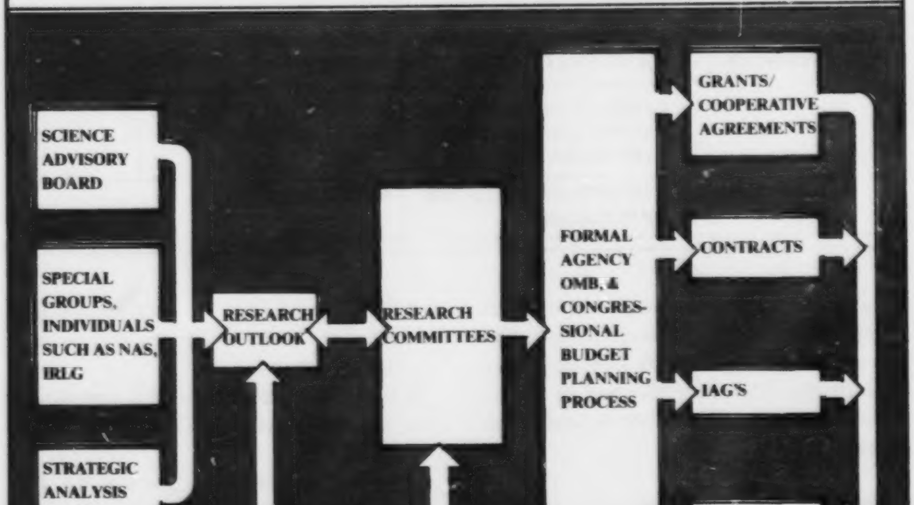
Further progress in the committee system has resulted from the recent ORD establishment of a Research Council to coordinate committee activities. The Council, chaired by ORD's Assistant Administrator, is composed of ORD co-chairmen from each of the thirteen committees and the Director of ORD's Office of Research Program Management. ORD's Deputy Assistant Administrators are ex officio members.

The concept of the Council grew from ORD's early recognition of the need to coordinate Committee activities in order to optimize the use of resources and to disseminate significant research findings to the many users of ORD's research results. The Research Council serves as a focal point for discussing multi-media issues, exchanging information related to committee activities, resolving issues of concern to two or more committees, and guiding the work of the committees. Overall, the Research Council serves as an integrating forum with a multimedia perspective.

The establishment of the Research Committees and the Research Council represents a major change in the way EPA plans research. Although the system has been in full operation for less than a year, the research program has already become focused more closely on the research needs of EPA. The coming years promise to continue the progress.

The Research Outlook. With the advent of the research committee system, future **Research Outlooks** will acquire new importance in the planning process. The **Research Outlook** will maintain a dynamic relationship with the Research Committees and with their main product, the research strategy. **Outlook** will give the committees guidance for deliberations, especially in revising the strategy; the research committee strategies, which specifically delineate research needs and plans, will, in turn, help to shape **Outlook.** The future **Research Outlooks** will also consider the results of strategic analyses and current research, such as anticipatory research, as well as insights from top environmental researchers.

The **Research Outlook 1980,** the fifth in



PLANNING AND IMPLEMENTATION SCHEME IN ORD

SCIENCE ADVISORY BOARD
SPECIAL GROUPS, INDIVIDUALS SUCH AS NAS, IRLG
STRATEGIC ANALYSIS GROUP
RESEARCH OUTLOOK
RESEARCH COMMITTEES
FORMAL AGENCY OMB, & CONGRES-SIONAL BUDGET PLANNING PROCESS
GRANTS/ COOPERATIVE AGREEMENTS
CONTRACTS
IAG'S
IN-HOUSE LAB WORK

RESEARCH COMMITTEES AND CORRESPONDING PROGRAM OFFICES

PROGRAM OFFICE	PROGRAM DAA'S OFFICE	ORD RESEARCH COMMITTEE	
OFFICE OF AIR, NOISE AND RADIATION	OFFICE OF RADIATION PROGRAMS	RADIATION	
	OFFICE OF MOBILE SOURCE AIR POLLUTION CONTROL	MOBILE SOURCE AIR POLLUTION	ENERGY COMMITTEE
	OFFICE OF AIR QUALITY PLANNING AND STANDARDS	OXIDANTS	
		GASEOUS AND INHALABLE PARTICULATE POLLUTANTS	
		HAZARDOUS AIR POLLUTANTS	
OFFICE OF WATER AND WASTE MANAGEMENT	OFFICE OF WATER PROGRAM OPERATIONS	MUNICIPAL WASTEWATER AND SPILL PREVENTION	
	OFFICE OF WATER PLANNING AND STANDARDS	INDUSTRIAL WASTEWATER	
		WATER QUALITY	
	OFFICE OF DRINKING WATER	DRINKING WATER	
	OFFICE OF SOLID WASTE	SOLID WASTE	
OFFICE OF TOXIC SUBSTANCES	OFFICE OF TESTING AND EVALUATION	TESTING AND ASSESSMENT	
	OFFICE OF PROGRAM INTEGRATION AND INFORMATION		
	OFFICE OF PESTICIDE PROGRAMS	PESTICIDES	

the series, is the first to consider the research committee strategies, although some strategies and this year's **Outlook** were developed concurrently. More effective use of the research strategies will be made in future **Outlooks.**

Research Planning Goals. EPA research planning goals over the next several years are to:

- Refine the strategies for all research committees;
- Refine and improve the research committee system as a whole;
- Synchronize the research committee schedule with the Agency's zero base budget schedule;
- Better integrate the research committees into the **Research Outlook** development;
- Ensure the prominent place of the **Research Outlook** in the planning process.

Responsiveness Through Better Management

In addition to the improvements made in EPA's research planning process, the Agency has also initiated several changes in its research management.

Organizational Changes. EPA has been under increased pressure to provide higher quality management of several key research areas. In 1979, the Office of Research and Development took a major step to respond to those pressures. ORD realigned its laboratory reporting relationships to consolidate functional or discipline groupings. This action established: 1) the Office of Health Research to manage health effects research, 2) the Office of Environmental Processes and Effects Research to integrate environmental transport, fate and effects research, 3) the Office of Environmental Engineering and Technology to integrate control technology and hazardous waste research, and 4) the Office of Health and Environmental Assessment (OHEA) to improve coordination of effects assessment activities. The OHEA will produce guidelines for several types of risk assessments required for development of EPA regulations. OHEA will also oversee the assessments prepared by regulatory program offices to ensure reasonable conformity to the guidelines.

ORD continues to experiment cautiously with matrix management approaches, primarily to improve the coordination and delivery of high visibility, short-term research products (e.g., the Diesel Particulates program). In the future, a limited number of similar matrix management programs—including the Acid Precipitation program—will be established.

Research Program Reviews. Credibility and integrity of all data generated for EPA decisions are essential. EPA has therefore acted during the past year to build appropriate review mechanisms into its scientific and technological efforts. The Office of Research and Development has issued guidelines for those reviews in order to distinguish between planning and resource allocation reviews and the reviews of ongoing research and technical results. In addition to routine laboratory reviews, the guidelines call for quarterly reviews of cross-cutting issues to provide the Assistant Administrator of Research and Development with fresh perspectives and sound judgments from scientific experts outside of ORD. Programmatic reviews conducted along the same lines as the research areas of the established Research Committees are encouraged. In all cases, ORD will attempt to strengthen outside advice and peer review.

Long Term Research and Grant Procedures. ORD is taking steps to assure that EPA addresses the most important future problems and attracts the best scientific talent to work on the problems. These steps mainly involve research grants, the primary mechanisms available for attracting the talent and supporting innovative ideas. ORD is endeavoring to make the scientific community more widely aware of research grants and is encouraging much greater competition for them; ORD is also attempting to ensure that grants are awarded on the basis of merit through enhanced peer review. Recent administrative actions to improve grants included a rigorous review of the existing grants procedure and subsequent recommendations for improvement. One improvement now being implemented is the creation of an Office of Exploratory Research to provide the organizational capability for anticipating emerging environmental problems and providing responsive research. The new office will also consolidate the tasks of scientific peer review and administration of research grants, this latter task to include an expanded research proposal solicitation system.

Improving Accountability. Effective management of research programs requires the monitoring of often-abstract performance indicators. Identification of the proper degree of monitoring and of the correct indicators is essential to achieve a balance between project accountability and management flexibility. ORD, in its attempt to attain that balance, has developed a system to reliably track projects to determine if they produce the critical outputs required by EPA Program and Regional Offices, as identified by the Research Committees. The tracking system is still being refined; current efforts are attempting to reduce the number of products that must be tracked. In another step to improve accountability, ORD has significantly streamlined the preparation of laboratory implementation plans which, taken as a whole, compose ORD's annual operating plan. One key streamlining action has been to focus the plans on project products, thereby enhancing accountability through better tracking and management. This and other changes have reduced the amount of paper, time, effort and cost associated with developing the operating plan.

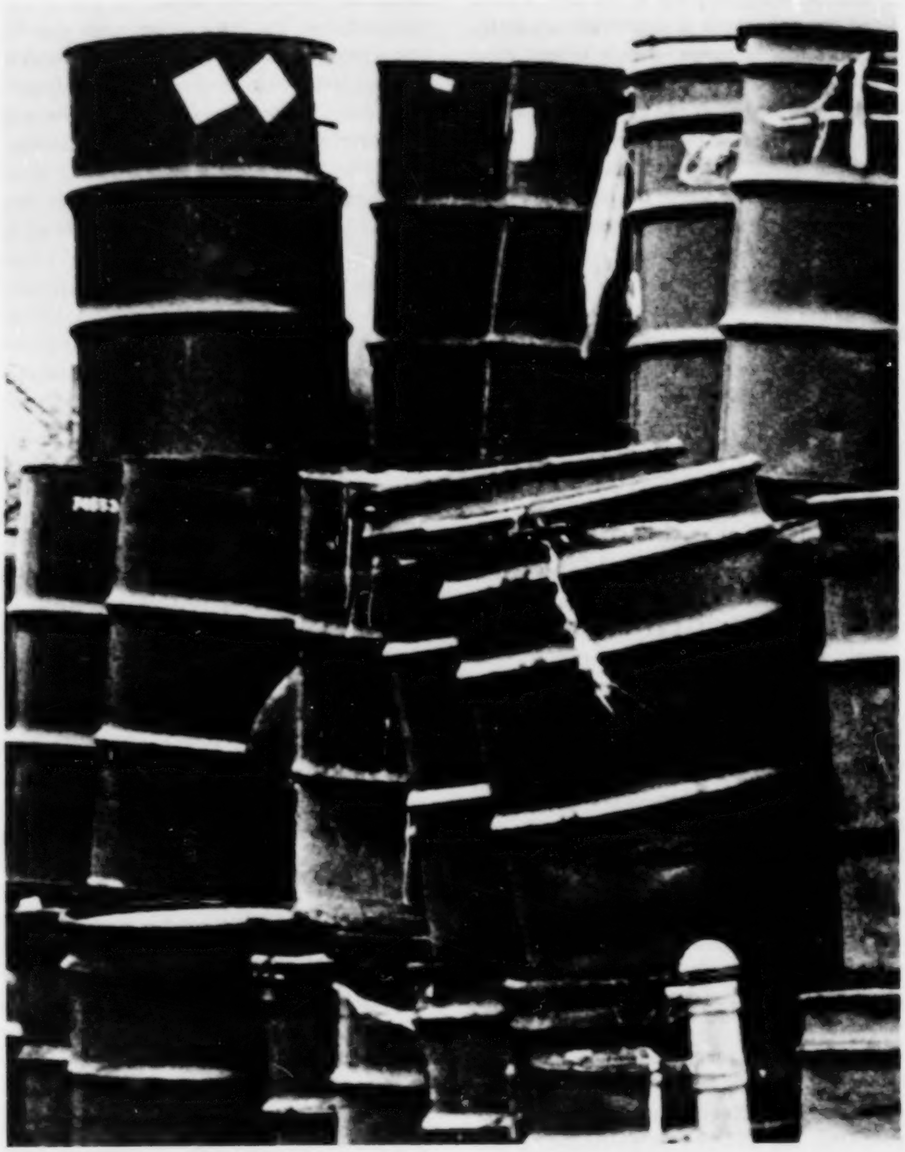
Accountability of the most important product of EPA's research program — the proven scientific information that it develops — will also be improved. In 1978, EPA-supported research resulted in more than 600 articles in peer-reviewed journals; during 1980, a new technical information policy will be implemented to improve the quality and to increase the flow of such information. Under this new policy, increased emphasis will be placed on publication of research results in respected journals and significant improvements will be made to the manner in which research information is communicated to those who need it. In a related step, a major technical information initiative is now underway to consolidate most of the information transfer activities pertaining to EPA's research program and to provide quality control of technical information products. The goal of this initiative is to improve both the scientific quality and the cost-effectiveness of EPA's research information output.

Research Management Goals

EPA research management goals over the next several years include:

- Enhancement of peer review
- Refinement of program review procedures, including Research Committee reviews
- Improvement of grant solicitation and review procedure, especially for long-term research
- Continuation of the matrix management experiment
- Development and improvement of a reliable tracking system.

TOXIC SUBSTANCES



Chemicals may pose risks to man and the environment. EPA is conducting research to understand those risks and to minimize them.

The fundamental purpose for EPA's toxic substances research is to provide accurate, scientifically rigorous, timely information and data collection methodologies to support decisions to regulate and control man-made toxic materials in the environment. This research effort may be viewed from two perspectives. First, under the broad authority granted EPA by the Toxic Substances Control Act of 1976 (TSCA), our research will develop methods to test and assess toxics and will gather and analyze information necessary for us to understand potential hazards posed by chemicals to human health and the environment. The second, and larger, perspective however is that many of EPA's other federally mandated research programs are in some way concerned with toxic chemicals and thus may be useful for solving the toxic substances dilemma. In fact, except for research of nonionizing radiation, noise, and some parts of our drinking water program which deal with bacteria and virus control, a significant portion of our research is now concerned with characterizing and controlling pervasive toxic substances.

Many of EPA's research programs are in some way concerned with toxic chemicals.

To effectively meet the toxics challenge, our research structure is designed to address the primary aspects of the hazardous chemical problem: the sources of pollution (e.g., energy production and manufacturing), the types of pollution (e.g., solid waste, particulate emissions), the receiving environmental media (e.g., air, water, sediment), and the effects related to each of these stages of a toxic's presence in the environment. This structure, which has evolved from combinations of past and present programs, takes advantage of the multidisciplinary scientific skills already assembled and organized to study particular toxics problems.

The research information we gather must meet the immediate needs of TSCA implementation; the information must also fill some gaps in our knowledge about methods to control long-term environmental pollution problems. But because our information is to support regulatory decisions, we must thoroughly understand and appreciate the goals of the regulators as well as the pressures they face. Their prime regulatory difficulty is, in essence, how to maximize social benefit from modern technology while limiting associated risk to a permissible level. This "maximum benefit at acceptable risk" is the foundation for the expanding body of Congressional regulatory legislation on the environment and public health.

Legislative Authority. Legislation to control toxic emissions consists of a number of federal laws to protect people and the environment from hazardous substances. These laws for the most part evolved from earlier public health protection efforts of limited scope and of different control philosophy. For example, the intent of major environmental legislation passed in the early 1970's was mitigation of pollutants in specific media after the fact, that is, after pollutants were already in the environment.

Two more recent pieces of legislation, TSCA and the Federal Insecticide, Fungicide, and Rodenticide Act of 1972 (FIFRA), are specifically written to prevent future hazardous contamination from new chemicals being placed on the market. These Acts stress protection of the total environment and were designed to supplement rather than override existing pollution control laws. A third piece of notable legislation, the Federal Water Pollution Control Act, sets effluent standards for 65 classes of pollutants and is thus the first law that mandates a toxic chemical control effort.

Research done under all of these mandates, we expect, will provide the necessary insights for government, industry, scientists, and the public to grasp the problems posed by toxic chemicals and may also heighten the general expectation that they will be corrected or prevented. But toxic chemical control will be neither immediate nor simple.

The Chemical Problem. Industrial data help illustrate the complexity of chemical control: In November 1977, the American

Chemical Society's registry of chemicals listed almost four and a half million distinct chemical substances—and this roster only included compounds cited in literature since 1965. The number of chemicals currently in commercial production in the U.S. is well over 40,000 with at least 50 substances manufactured in amounts exceeding 1.3 billion lbs/yr. The $113 billion generated per year through production and distribution of chemicals by over 115,000 businesses accounts for 7% of the U.S. Gross National Product. Today, a direct relationship exists between the escalating industrial growth in our country and sharp increases in the production and use of chemicals. These increases are projected to continue with, for example, a high demand in the plastics industry for such basic organics as vinyl chloride, styrene, and propylene oxide. Yet, while these and other manufactured chemicals may be used in medicines, in the production of more and better consumer goods, and in fertilizers that increase food production, the risks they pose cannot be ignored.

The frequency with which toxic substances occur in the environment and the adverse effects attributed to them have both increased markedly in recent years. Of note, a number of substances now known to be adverse to human health such as mercury, kepone, chloroform and chlorinated dioxins, were not so identified until after having caused their damage. Therefore, the crux of the toxics control dilemma is how to anticipate the existence of such substances and circumvent their deleterious impact.

A number of substances have been identified that require priority investigation and possible regulation.

Since research into chemical usage has been largely limited to the study of acute toxic effects, little is known about the environmental transport and fate, biological pathways, and the chronic long-term effects of most substances. Contributing to our lack of knowledge is a shortage of laboratory facilities and professionals trained in toxicology, industrial hygiene, pathology, and other relevant disciplines.

Based upon the information we do have, however, a number of substances have been identified that require priority investigation and possible regulation. The following give even more urgency to our work:

- PCBs (polychlorinated biphenyls) are appearing in fish at unacceptable levels in fisheries across the nation. Although banned for unenclosed uses since July 1, 1979 by TSCA, PCBs will remain as persistent toxic agents in the sediments of streams, lakes, and coasts. Substantial amounts of PCBs are also contained in sealed capacitors and transformers.
- Preliminary laboratory test results indicate that some diatoms, algae, and phytoplankton (the foundation of the marine food chain) are sensitive to ultraviolet light and may be endangered if worldwide emissions of ozone depleting substances continue, allowing progressively more ultraviolet light to pass through the ozone layer of the atmosphere.
- The Love Canal landfill in Niagara Falls, New York was recently discovered to be the disposal site for over 21,000 tons of chemical wastes including highly toxic substances such as benzene hexachloride, hexachlorobutadiene, trichlorophenol and dichlorobenzene, etc.; over $2 billion in personal liability damage claims have been filed due to chemical leakages.
- A two-year study conducted by the Environmental Defense Fund and the New York Public Interest Research Group has found that the Hudson River is contaminated by a spectrum of toxic substances including PCBs, benzene, xylene, cyclohexane, tetrahydrofuran, toluene, and chloroform.
- Asbestos fibers have been found in the lungs of most persons tested. According

RECOGNIZED HAZARDOUS AGENTS*

CHEMICAL	USE	HAZARDS	EPA REGULATORY ACTIONS
Acrylonitrile (AN)	manufacture of acrylic fibers, synthetic rubbers and plastics	highly toxic; possibly carcinogenic and teratogenic	risk assessment for new performance standards for air emissions
Arsenic	pesticides and manufacture of glass	poisonous; causes dermatitis, muscular paralysis, damage to liver and kidneys; possibly carcinogenic and teratogenic	investigation of air exposure to arsenic; review of uses in fungicides and herbicides
Asbestos	roofing, insulation, certain cement pipe, flooring, packing and gaskets, friction materials coating, plastics, textiles and paper	carcinogenic to industrial workers and immediate families	assessment of sources and uses; planning of new regulations under Clean Air Act for existing buildings
Benzene	octane booster in gasoline; manufacture of numerous other chemicals	causes leukemia and chromosomal damage in exposed workers	listing as hazardous air pollutant; analysis of population health effects to assess risks and determine control options
Beryllium	manufacture of rockets and airplanes, ceramic parts and household appliance circuitry	causes fatal lung disease, heart problems, enlarged liver and spleen, kidney stones and cancer	controlled under hazardous air pollution standards effective 10/77
Cadmium	electroplating; in certain plastics, pigments and other products	causes kidney damage and emphysema; possibly carcinogenic, teratogenic and mutagenic	studies to regulate air sources based on health impacts, carcinogenic risk sources, and environmental impacts of control options; use as fungicide under review
Sulfur dioxide	preservation of fruits and vegetables; disinfectant in breweries and food factories; bleaching of textile fibers; solvent	intensely irritating to the eyes and the respiratory tract; causes extensive corrosive environmental damage	setting of criteria revision schedules 5/80, as EPA criteria air pollutant
Vinyl chloride (VC)	plastics; refrigerant; organic synthesis	systemically toxic; carcinogenic	proposal of VC hazardous air pollutant amendment 6/2/77 to reduce emissions to zero
Lead	tank linings and pipings storage batteries, ceramics, plastics, and electronic devices; gasoline additive	intoxicant and poison; causes additional subclinical effects	setting of ambient air standards; revision of national primary drinking water regulations; criteria set for lead in ambient waters; setting of industrial effluent guidelines and levels in solid wastes; analysis of environmental and economic impact

RECOGNIZED HAZARDOUS AGENTS*

CHEMICAL	USE	HAZARDS	EPA REGULATORY ACTIONS
Mercury	electrical apparatus; preparation of other chemicals; medicines and pharmaceutical products; paints and pesticides	causes severe nervous system damage and kidney destruction	controlled under hazardous air pollution standards effective 10/77
PBBs	flame retardant	accidentally mixed with animal feed in 1973, causing possible human illness and the destruction of thousands of farm animals	investigation of the need to regulate manufacture and use as flame retardant
PCBs	insulation for heavy duty electrical equipment	possibly carcinogenic; causes nerve, skin and liver damage	setting of final rule prescribing disposal and marking requirements effective 4/18/78; ban on production (as mandated by TSCA) proposed 6/7/78
Chlorinated solvents	dry cleaning and degreasing operations; aerosol sprays, paints, certain cleaners and pesticides	cause depression of the central nervous system and heart functions, liver problems; possibly carcinogenic	regulation plans for chloroform in drinking water, and for perchloroethylene under Clean Air Act
Chromates	paints and pigments, fungicides, wood preservatives and corrosion inhibitors	cause skin ulcers and kidney inflammation; possibly carcinogenic; toxic to fish and other animals	revision of 1976 drinking water and water quality standards; listing as hazardous substance under FWPCA §311
Coke oven emissions	emitted in coke production for the iron and steel industry	cause lung cancer and other illnesses	determination of whether to list as "new source or hazardous" pollutant under Clean Air Act; Water Programs assessment to propose effluent guidelines
Dibromochloropropane (DBCP)	soil fumigant; nematocide	causes sterility and cancer	review of pesticide use
Ethylene dibromide (EDB)	additive in leaded gasoline; pesticide; solvent and intermediate industrial chemical	possibly carcinogenic, mutagenic and teratogenic	Environmental Defense Fund petition (8/77) to regulate; review of pesticide and other uses
Ethylene oxide	auto antifreeze; sterilization of medical equipment	mutagenic in humans; causes testicular damage; eye and respiratory tract irritant; skin blistering agent	review of uses as insecticidal, fungicidal, and bactericidal fumigant

*Taken from "Hazardous Substances" (EPA, November 1978) and The 9th Annual Report of the Council on Environmental Quality (1978), pp. 186-192.

to researchers at the University of Chicago, asbestos particulates that have an iron-containing coating, are present in 96 percent of urban dwellers who have been examined. Despite OSHA and EPA standards for occupational exposure and air emissions, there is growing concern that public exposure to asbestos generally may be increasing.

Regulation Under TSCA. TSCA is designed to help eliminate existing and future threats to public health and to the environment posed by toxic substances. Several key provisions within TSCA serve to fill gaps in earlier-promulgated mandates.

- manufacturers and/or processors may be required to test new and existing chemicals for potential health and environmental effects;
- a premanufacture notification process is required for all new chemicals and chemicals proposed for significant new use (although certain exemptions are possible);
- EPA can limit processsing, production, distribution, disposal, or use of chemicals to prevent unreasonable risks to health or environment (providing that regulation under other statutes is not more appropriate);
- reports may be required to provide information concerning the commercial distribution and exposure of toxic substances; health and safety studies may also be required.

The Implementation of TSCA. To date, TSCA implementation has involved definition and initiation of preliminary test schemes and assessment approaches. Over the next 5 years EPA will revise and expand health and environmental effects test methods and will develop standards for characterizing chemicals and their fate. Standards for environmental effects testing will likewise be developed.

Toxic Substances Research and Development Program

Three goals provide the framework for ORD's toxic substances research program: provide specialized technical assistance to resolve complex problems, develop research capabilities to meet TSCA implementation time frames, and develop a comprehensive long-range program to continuously refine test methods and assessment schemes.

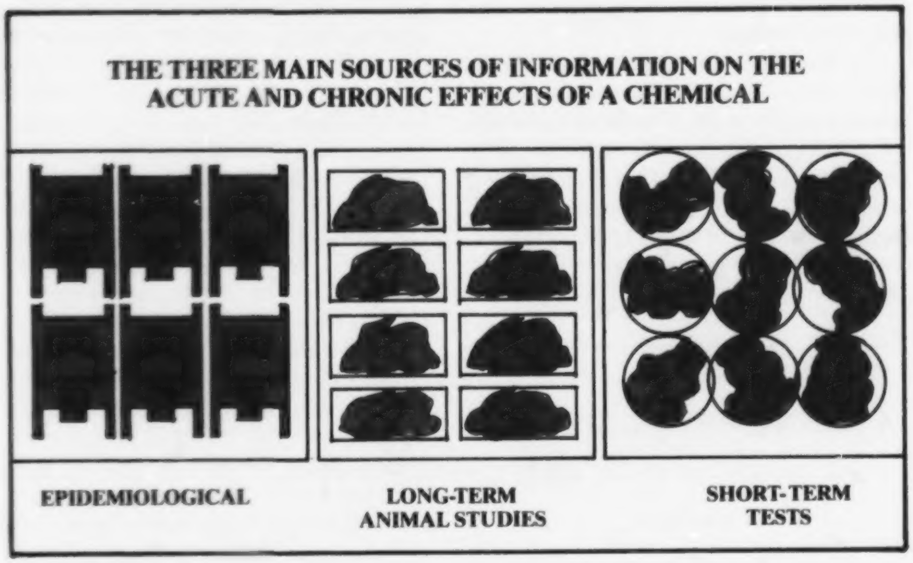
ORD will support EPA's toxic substances program by providing the expertise and methodology for required tests and by aiding the Office of Pesticides and Toxic Substances (OPTS) in toxic substances hazard and exposure assessment. OPTS will require improved hazard assessment test evaluation procedures, both to analyze data from industry sources and to support its own results for regulatory purposes. Improved exposure assessment tests will give additional depth to the program by allowing EPA to clearly evaluate exposure levels from a variety of pollutants and the consequent hazard they pose to humans and the environment. Exposure parameters to be documented include toxic chemical release, fate, use, distribution, and disposal.

Chemicals of specific regulatory and research interest will be studied.

Additonally, ORD will aid OPTS in a number of special projects not necessarily in response to any one section of TSCA. Chemicals of specific regulatory and research interest will be studied, as will improved methods for risk assessment. Exploratory and confirmatory studies such as the biological or climatic impacts of stratospheric ozone reduction will also be undertaken. Thus, ORD's research program will effectively converge with EPA's effort within OPTS to implement TSCA by studying, evaluating, and documenting the health and environmental impacts of toxic substances.

ORD's program is designed to support EPA's toxic effort by:

(1) developing first generation testing standards to define health and ecological effects;



THE THREE MAIN SOURCES OF INFORMATION ON THE ACUTE AND CHRONIC EFFECTS OF A CHEMICAL

(2) providing analyses of ambient pollutant transport and fate;
(3) determining the ambient presence of selected toxic substances;
(4) recommending alternative manufacturing process options for the processing and/or production of potentially hazardous or toxic materials;
(5) providing technical expertise and specialized equipment to agency operating programs.

Most FY 80 research activities supporting TSCA will continue into the future. FY 80 budget increases will both expand base programs and provide resources for ORD's Public Health Initiative (PHI), the first toxic substances program that assesses their environmental pathways and integrates this data with human exposure and adverse health effects. PHI identifies the value of using predictive models in assessing risk and hazards and responds to the need for more and improved programs which have direct bearing on health and environmental quality.

Program Strategy. Four study areas provide the framework for EPA's overall toxics research program: (1) health effects, (2) environment, (3) monitoring support, and (4) industrial processes.

Each of these areas requires the development and application of validated measures and techniques to assure quality. Our quality assurance program will cover personnel, methods, equipment and data handling procedures to guarantee the precision and accuracy of data bases used for risk assessment and regulatory decisions. This program will be applied to each of the Agency study areas individually and as they function in EPA's integrated toxics research system.

Health Effects Research

Historically, testing chemical substances on experimental animals to predict toxicity in humans has concentrated on acutely lethal effects. Now, however, we are giving more consideration to delayed or cumulative toxic effects. These effects are being measured through tests capable of determining chronic toxicity through examination of diseased organic tissue. A number of factors, however, complicate all toxicity testing. Past tests and experience have confirmed, for example, that the route of entry of a toxic substance into a body dramatically affects the nature of its toxicity. Other factors include differences in species and/or sex sensitivities or susceptibilities, as governed by metabolism and hormonal controls.

To date our research has been specific to investigation of single chemicals, but now needs a broader scope to facilitate the design of convenient, valid model systems that more completely define human health effects. We also need to know more about the kinds of toxicity that may be escaping our detection; more prospective-predictive research is needed.

More prospective - predictive research is needed.

Strategy. The Agency's research program follows four basic lines of inquiry: (1) What is the full range of human diseases stages that could result from exposure to environmental chemicals and chemical classes? (2) What are the appropriate test systems and/or animal species that may be cost effectively and reliably employed to detect chemically induced disease processes? (3) What critical life processes impact quantitative extrapolation between species? and (4) How does man's sensitivity to particular types of toxicity correlate to that of various test species?

Extrapolation to Man. Knowing the biochemical and physiological similarities and differences between man and experimental animals is necessary to construct test systems that can quantify responses relevant to humans. Yet while such correlating information has the largest impact on our regulatory decisions, our understanding in this area is only rudimentary. This could lead to, for example, the acceptance of a substitute substance more toxic to man than the compound it replaces. We also have the need for epidemiologic research to determine *post facto* toxicity in humans.

Target Organ Toxicity. A considerable amount of our target organ research is directed at studying the nervous system, a specific target for most toxic substances. Our neurotoxicology efforts will concentrate on the evaluation of promising neurobiological test methods. (A1, A2, A3, A4) Ultimately, we will select those tiered tests (screening, evaluation, and risk assessment levels) that prove most appropriate to the regulatory process. (B8, B9, B10, B11) Other significant target organs include the cardiovascular, pulmonary, reproductive, endocrine, renal and hepatic systems, and the exocrine processes. (B1 through B7, B12 through B20)

Mutagenesis. Existing test systems require further refinement to acquire the desirable characteristics of specificity, reproducibility, high sensitivity, and ease of performance. Tiered testing will include study of point (gene) mutation, chromosomal alterations, and primary DNA damage and repair. We will also study existing bioassays to determine their genetic basis and apply this knowledge to develop new mathematical models for mutagenesis hazard assessment. (D4, D5, D6, D7)

Carcinogenesis. The fact that mutagenic activity in short-term tests seems to correlate with carcinogenic activity in whole animals allows mutagenesis tests to be used in screening chemicals for their potential carcinogenicity. Key first-level carcinogenesis tests include the Ames *Salmonella* mutagen assay and *in vitro* and *in vivo* cytogenetics. The Agency is also developing improved second-level tests with a greater sensitivity to carcinogens, and greater accuracy for measuring such factors as pharmacokinetics. (D1, D2, D3) In the future, it is thought that such second-level tests may supplant third-level tests (full-term, chronic testing) thereby significantly reducing the costs of risk assessment testing.

The nervous system is a specific target for most toxic substances.

Teratogenesis. The significance of the wide range of embryonic and fetal changes witnessed in test animals must be researched. We are also lacking the ability to extrapolate animal data to human populations, particularly in terms of dose-response and threshold effects. Further study must be made of *in utero* exposures that may alter postnatal functions of a wide variety of organ systems. (C1 through C7)

Metabolism. Studies of the effects of toxic substances on test organisms' metabolism will facilitate: (1) determining which species is most proximate to man, (2) identifying those metabolic processes involved in synergisms and antagonisms; (3) clarifying the role of toxics bonding to DNA in mutagenesis/carcinogenesis testing and hazard assessment. Because of the wide differences between species being tested, all our toxic substances studies must include examinations into the intrinsic sensitivity of a given species, as well as its general metabolic response to foreign substances. (D8 through D20)

Environmental Research

The need exists for an investigation into the ecological effects and chemical fate (transport and persistence) of various compounds in the environment. In order that those substances that are toxic can be identified prior to their causing environmental damage, EPA must (1) develop test methods and assessment schemes to define the exposure, hazards, and risks posed by toxic substances; (2) develop screening methodologies for the rapid evaluation of large numbers of chemicals; (3) transform state-of-the-art techniques into schemes for use in initial TSCA implementation.

Testing Methodologies. We will be developing methodologies for testing ecological effects and environmental fate of toxic substances as mandated by TSCA. Our ecological effects tests are developed to assess:

- Adverse effects of substances on certain species which may, in turn, result in significant ecological damage;
- Indirect human exposures and impacts resulting from the uptake and concentration of substances by a given species; and
- Potential impacts of toxic substances on humans by evaluating specific effects on other species and on ecosystems.

In developing these tests, emphases are placed on cost effectiveness and simplicity. Among the many research areas studied are: the food chain system, the plant and animal life cycle, behavioral toxicology, pollen assays, algae and phytoplankton assays, and plant and animal uptake studies.

Emphases are placed on cost effectiveness and simplicity.

Environmental fate tests define what happens to a chemical once it is introduced in the environment, that is, in which part of the environment (air, water, soil, and biota) the chemical may accumulate, and for how long and in what form the chemical will persist. Fate tests are necessary to provide data for exposure assessment. Current environmental fate research will be used to produce support documents for testing of existing chemicals and premanufacturing testing to be carried out by industry. These documents will better define test limits and applicability and, where possible, indicate how tests might be made both more cost effective and broadly applicable. Other environmental fate studies being conducted include: (1) development of improved methods for estimating volatility of chemicals in water; (2) definition of relationships that exist between various physical chemical properties of soil/sediments and the measured adsorption and desorption isotherms; (3) development of methods to assess biodegradation processes, and reactions of toxic chemicals in air. (E1 through E5, E8)

Screening methodologies under development are capable of predicting the biological activity of toxic substances as well as their fate characteristics. Such screening techniques will be especially helpful in identifying a chemical's potential for causing adverse effects in more advanced testing. In the future, screening methods will be capable of estimating chemical transport, fate and effects in laboratory ecosystems and microcosms. However, considerable advancements will have to be made before chemicals can be effectively screened in such microcosms. Among the extensive research supporting this future objective are studies of: structure/activity relationships, comparative toxicology, ecosystem process methodology, behavioral toxicology, biochemical/physiologic responses, and methodologies for predictive models. (E6, E7, E9, E10)

Exposure Assessment Models. Data derived from health effects screening research will provide a basis for developing mathematical models for estimating potential exposures to toxic substances. Mathematical models are now being developed to estimate how and where toxic chemicals enter various environmental media (loadings), their transport, degradation and distribution (exposure) characteristics, and their impacts on humans and the environment (dose responses). These models will allow EPA to tie quantitative estimates of human and environmental effects to projected loadings of a particular toxic chemical into the environment. Thus, the environmental risks associated with various management alternatives can be estimated and cost-effective regulatory and management enhanced.

Environmental risks associated with various management alternatives can be estimated.

Corresponding exposure models for air, terrestrial, estuarine, and marine environments are also under development, along with basic dose response models for various critical species of aquatic and terrestrial organisms, including man. Properly integrated, these models will provide the basis for multimedia risk assessments. (F1 through F6)

Currently, mathematical model results are being compared with analytical data obtained from a wide range of laboratory and field ecosystems to determine the validity of the model's conceptual basis. For these tests, controlled ecosystems such as macrocosms, channels, field plots, etc., are dosed with a toxic chemical and the resulting concentrations, distributions, and effects are measured. These data are compared with the results derived from models that represent the specific environmental conditions existing in the controlled ecosystem. Such tests are crucial to the ultimate use of the model; only after they are successfully completed can engineering testing begin to assess the model's utility. These engineering tests must balance cost and performance; therefore, the model's scale and resolution are tuned to achieve a desired level of output at an appropriate cost. (F7 through F10)

Engineering tests must balance cost and performance.

Monitoring Support

Monitoring is the means by which we characterize and quantify toxic chemicals in the ambient environment; this is essential for evaluating risks to man and the environment. Much of the data collected under TSCA will be provided by monitoring programs supported by other environmental legislation.

Three major activities characterize ORD's monitoring program: (1) methodology development and measurement systems research, (2) field collection methodology and monitoring activities, and (3) quality assurance. These efforts complement TSCA by: (1) filling gaps in the data base on existing chemicals; (2) assessing exposure to specific substances, and (3) assessing the effectiveness of TSCA control strategies.

Methodology Development and Measurement Systems Research. This research area seeks to develop methodologies for identifying and quantifying new and existing toxic chemicals or their major degradation products in air, soils/sediments, biological matrices, and commercial products. Such toxicants vary widely in chemical characteristics and detectability and will continue to present detection and analytical complexities for us well into the future. A vigorous, broadly based analytical chemistry program is therefore mandatory. In addition, the large quantities of samples that require analyses for TSCA implementation creates a need to increase the speed with which samples can be handled and to reduce per sample costs. Existing chemical screening methods will be streamlined, and nonextractive multi-element methods will be developed. (G1 through G9)

Existing chemical screening methods will be streamlined.

Current methods for collecting and analyzing toxic organics in the atmosphere are inadequate. Systems must be designed that are sensitive to the specific differences of the various geographical areas of the country. Techniques for separating complex mixtures in air samples must be improved. (G9) Research will be conducted to develop appropriate sampling and analysis techniques for the full range of potentially toxic organic materials. This effort will include a new initiative to deal with the tracking and control of toxic air pollutants.

Our knowledge concerning the measurement of organics in soils/sediments and sludges is severely limited. Those soils/sediments and sludges are, however, major sinks for many toxic chemicals. Thus, our research will have to develop methods to separate, characterize and quantify toxic chemicals that bind to these media. (G13)

To minimize the efforts put into expensive quantitative analysis, research into additional biological monitoring methods will be undertaken to develop a series of qualitative screening methods to indicate the presence of specific pollutants in biological systems. The first method to be developed will be for the extremely toxic substance, tetrachlorodibenzodioxin.

Commercial products are another source of trace organics that we will address in our research effort. Identification of these toxic substances will be achieved through separation techniques, such as solvent extraction ion exchange and selective absorption and volatilization. The identification techniques used will also be evaluated to establish their suitability to detect impurities. Validated methods can then be used for the testing required by TSCA. Efforts will focus on determining trace levels of PCBs. (G1, G2, G3)

Field Collection Methodology and Monitoring Activities. Field studies are necessary to develop and/or apply improved data collection techniques. In our field studies, we will concentrate on collecting data on those pollutants pertaining specifically to TSCA or to enforcement actions.

Future program emphasis will shift to developing field monitoring techniques.

Our major effort to date for measuring ambient levels of air pollutants has involved the use of the gas chromatograph/mass spectrometer (GC/MS) to screen for nearly 100 organic compounds collected from various industrial facilities. While we will continue to refine GC/MS data collection/sample preparation and extend our known toxic materials spectra data bank, future program emphasis will shift to developing field monitoring techniques. (H1 through H7)

We will continue to validate environmental models that predict ambient pollutant transport, fate and/or effects to determine the degree of their accuracy. A series of protocols, or "how to" manuals, will be developed that will describe field programs designed to collect the data necessary for model validation. (H4, H5, H7)

Quality Assurance. The quality assurance program will function as a reviewer of both EPA's environmental monitoring program, and the research supporting the standardization of monitoring methods and protocols under TSCA.

The program will also assist OPTS by developing guidelines for good laboratory practices, to be used by industry in response to TSCA testing protocol requiremetns for environmental effects. Additional assistance will be provided as needed for drafting the quality assurance sections of specific testing protocols. (I1 through I4)

Industrial Processes Research

EPA will continue to carry out systematic assessments to identify the toxic pollutants discharged to air, water, and solid media by chemical manufacturing processes. This work originally focused on product-specific commercial processes, such as those used to produce trifluralin, atrazine, nitrobenzene, aniline, alkyl amines and acrylonitrile. However, our emphasis has recently shifted to achieve broader industry coverage by focusing on the toxic discharges and product contaminants from generic processes such as halogenation, amination, oxidation, and nitration. In the future, generic process toxic discharges for a number of chemical process industries, including pesticides, industrial chemicals, pharmaceuticals, food additives, petroleum refining, textile fibers, and dyes and inks, may be examined. (J1, J3, J4)

The Organic Chemical Producers Data Base (OCPDB) is an information source receiving increased use by the regulatory offices of the Agency. Recently, OCPDB has been expanded to include information on potential hazards involved in the production and use of some 600 organic chemicals. Further OCPDB expansion will include data on the various satellite industries such as plastics, dyes and pigments, pharmaceuticals, etc. Additionally, it has been proposed that data on the exposure potential inherent in various chemical uses be developed. Also, further work on structure-activity relationships will be investigated as the relate to carcinogenicity. This information will be of particular value to OPTS in assessing the potential hazard involved in a given chemical's manufacture and use.

We will be paying special attention to highly toxic co-products and by-products that are formed in the manufacture of important industrial chemicals. First to be studied will be chlorinated dioxins, formed as by-products in the manufacture of certain herbicides and wood treating chemicals. This study will include the preparation of a comprehensive report on the occurrence and properties of chlorinated dioxins. Additionally, technical assistance will be provided at locations where the occurrence of chlorinated dioxins in industrial waste is a serious problem. The assistance will include recommendations of applicable methods for destruction/detoxification. (J2)

Through in-process evaluations of specific manufacturing processes, the toxic chemical(s) inadvertently generated and introduced into products can be ascertained. Such evaluations can also pinpoint those in-process toxic chemical sources that will require regulation under TSCA and other applicable statutes. Over the next five years, we will focus upon developing alternative manufacturing methods and operating conditions so as to reduce toxic product contaminants. Further, we will evaluate the possibility of developing substitutes for chemicals that pose toxic threats.

Over the next five years, EPA will continue its research into sophisticated toxic chemical treatment or destruction technology with the ultimate goal of developing zero-pollutant-discharge manufacturing technology. (J5) This effort will be international in scope and will include cooperative ventures with other agencies, universities, and industry. (J6)

TOXICS RESEARCH PLAN

PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
HEALTH EFFECTS					
Development of a National Neurotoxicological Research Facility	Acquire and implement computer systems to support neurotoxicology research programs in developing a battery of short-term test procedures to evaluate neurotoxic responses. **A1**	Implement neurochemical and morphological indicators of the effects of toxic substances. **A2** Validate and implement a battery of tests for the effects of toxic substances on learning, memory and performance in non-human primates. **A3**		Validate and implement a battery of tests for the effects of toxic substances on learning, memory and performance in non-human primates. **A4**	
Target Organ Toxicity —Immune System	Determine the relative sensitivity of a battery of standard immunologic parameters to toxic substances in the mouse. **B1** Develop an animal model for evaluating the effects of toxic substances on immunosurveillance against tumor cells. **B2**	Determine the applicability of existing models for effects of toxic substances on pulmonary defense against infectious respiratory disease. **B3** Validate the animal model's utility with oral and inhalation routes of exposure to toxic substances. **B4**	Test the effects of inhalation of selected chemicals from several chemical classes using the pulmonary infectivity model. **B5**	Compare the sensitivity of the infectivity of model to other assays of host defense mechanisms. **B6**	Correlate *in vitro* to *in vivo* exposure models. **B7**

TOXICS RESEARCH PLAN(CONT'D)

PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
—Nervous System	Evaluate the visual-evoked-response as an indicator of neurotoxicity. **B8**	Evaluate the sensitivity of various testing procedures for the measurement of locomotor activity. **B9**	Develop and validate developmental neurotoxicology (behavioral teratology) testing procedures in rodents. **B11**		
		Compare methods for the rapid evaluation of the effects of toxicants on learning in rodents. **B10**			
—Reproductive System	Develop procedures to assess motility and viability of sperm cells. **B12**	Improve testing procedures to assess sperm count techniques. **B13**	Characterize and validate known chemical agents producing comparable toxic effects for predictive effects in man. **B15**		
		Publish report on chemically-induced alterations in sexually dimorphic patterns including correlations of anatomical and behavioral differentiation, fertility, fecundity and the ontogeny of infertility. **B14**	Develop FSH, LH, FSH-RH, LH-RH, and steroid profiles in male and female rodents. **B16**	Evaluate *in vivo* and *in vitro* HCG, LH and pituitary extract stimulated leydig cell testosterone production. **B17**	Investigate the physiology of lactation and the transport of toxic compounds to sucklings. **B18**
—Cardiovascular System		Initially define chemical classes which impact cardiovascular functional pathology. **B19**	Compare the white carneau region with other species as a means for detecting atherosclerosis. **B20**		

PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
Teratogenesis	Develop values for fetal hepatic glycogen, EKG's, renal alkaline phosphatase, pulmonary lecithin/sphingomyelin ratios, and CNS protein and DNA in normal fetal development. C1 Study the relationship of maternal toxicity to the outcome of embryonic and fetal development. C2 Report the results of experiments to validate proposed short-term *in vivo* screen by the testing of a significant number of diverse compounds of known teratogenic potential. C3	Final report of research on the relationship of morphological and functional cardiac alterations in mammalian fetuses with their ECG's. C4 Reports on feasibility and significance of ultrasonic vocalizations in neonatal rodents as an indicator of the general health status of neonates exposed to toxic substances *in utero*. C5	Report the quantitative and qualitative responses of the fetal development of rodent and nonrodent species (including man) to aminopterin. C6	Effects of selected chemicals on functional toxicity in fetal organ systems and the postnatal sequelae of such toxicity. C7	

TOXICS RESEARCH PLAN(CONT'D)

PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
Carcinogenesis and Mutagenesis	Examine an augmented cellular activation system for detecting carcinogens. **D1**	Develop a bladder cell cocultivation system for identifying mutagens. **D4**	Report on potency correlations between results in short-term mutagenicity /carcinogenicity bioassays and long-term carcinogenicity bioassays. **D7**	Report on systems for detecting chemically induced aneuploidity. **D10**	Report on specific gene mutation assays using cells from exposed humans. **D11**
		Determine the potential of the L-5178Y mouse lymphoma assay to detect both gene mutation and chromosomal alteration involving the thymidine kinase locus. **D5**			
	Evaluate the extent of DNA binding of chemical carcinogens in sensitive and resistant rodent strains. **D2**	Begin investigations into the DNA repair response in selected strains. **D6**	Continue comparative DNA repair studies and complete *in vivo* metabolic analysis. **D8**		
	Evaluate five selected chemical carcinogens for response via topical and parental application in the SENCAR system. **D3**		Evaluate five selected chemical carcinogens for skin tumor response in the SENCAR system following oral application. **D9**		
	Isolate and identify the adduct of one chemical carcinogen to hemoglobin for use in epidemiology studies. **D13**	Determine interspecies differences in the level and type of adduct formation. **D14**	Field trial of methodology in human study population with two chemicals. **D16**	Develop methods for different chemical adducts. **D17**	Finalize hemoglobin adduct system. **D20**
		Determine the relative potency of 12 chemical carcinogens in the hepatic island assay. **D15**		Apply methodology to field project. **D18**	
				Assess an additional 12 chemicals in the hepatic island system. **D19**	

PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
ENVIRONMENTAL RESEARCH					
Testing Methodologies	Validate algal assay methods for testing of toxics. **E1** Validate Daphnia life-cycle test for toxics. **E2** Validate test for toxics in embryo/larva stages of fathead minnows. **E3** Testing protocols for evaluating the persistence of toxics in air. **E4**	Standard methods for octanol/water partition coefficient determination. **E5** Microcosm for screening of toxics in marine organisms. **E6** Structure-activity concept for predicting toxicity and ecological effects of toxics. **E7**	Protocols for leaching of chemicals in soils. **E8** Structure-activity concept for predicting, transport and fate of toxics. **E9** Multiple assay techniques for interspecies interaction. **E10**		
Exposure Assessment	Testing of EXAMS using large laboratory neo-systems. **F1**	Data system for monitoring population exposure and estimating techniques. **F2** Models for predicting transport and fate of toxics in soils **F3** Quantitative models for toxics in the marine environment. **F4** Microcosms for predicting concentration of toxics in the terrestrial environment. **F5** Models for predicting toxic concentration in air. **F6**	Prototype environmental model for toxic concentration prediction in multimedia environments. **F7**	Preliminary evaluation of food chain models. **F8**	Terrestrial models for assessment of exposure to toxics. **F9** Validate models developed for predicting toxic concentration in air. **F10**

TOXICS RESEARCH PLAN(CONT'D)

PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
MONITORING					
Methodology Development and Measurement System Research	Determine effectiveness of brake cleaning methods in limiting asbestos exposures. **G1** Determine effectiveness of dye tracers for detecting freon leaks from automobile air conditioners. **G2** Method for measuring PCB's in oil. **G3**	Publish method for routine analysis of aldicarb. **G4** Feasibility of microbial systems for rapid detection of dioxin. **G5** Complete "production type" GC/FTIR system and protocol for analysis of dioxin in environmental samples. **G6**	Extend "production type" GC/FTIR system to specified pollutants. **G7** Publish methods for measuring specific organics in sediments. **G8** Publish streamlined method for multielement analysis. **G9**	Publish method for measuring organics in marine systems. **G10** Feasibility of microbial systems for rapid detection of specific organic compounds. **G11**	Publish methods for measuring toxics in specific products. **G12** Publish methods for specific organics in sediments. **G13** Publish method for use of microbial system for rapid detection of specific pollutants. **G14**
Field Collection Methodology and Monitoring Activities	Publish field methods for three specific chromophoric compounds including benzidene (air measurements). **H1** Publish field methods for separation and analysis of polar and hydrophilic compounds (air measurements.) **H2**	Publish field methods for screening specific toxic air pollutants. **H3** Collect monitoring data at selected sites for assessment studies. **H4**	Publish protocol on multimedia field procedures to validate a stream model. **H5**	Publish field methods for screening additional toxic air pollutants. **H6**	Publish protocol on-multimedia field procedures to validate selected model. **H7**

PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
Quality Assurance	Publish good laboratory practices guidelines for transport and fate and environmental processes. **I1** Publish quality assurance protocol for measuring asbestos in ceilings. **I2**	Implement mandatory quality assurance program. **I3**	Develop guidelines and protocols as required. **I4**		
INDUSTRIAL PROCESSES	Develop and initiate testing of model to indicate toxic environmental risk resulting from the manufacture of a chemical. **J1** Prepare reference manual on dioxins to include (1) sources, (2) degradation and transport, (3) disposal and decontamination, (4) toxicity, (5) sources of human exposure, (6) analytical methods, and (7) regulatory considerations. **J2**	Provide an updated model of economics and costs in the chemical process industries: • structure of the chemical industry • market movements • market practices • research and development and innovation in the industry • toxics impact assessment **J3**	Extend chemical industry model and: • Develop systematic method for selecting chemical substances for investigation or for regulatory action under TSCA. • Provide technology assessments on production/use/consumption/disposal of priority pollutants. • Prepare integrated assessment on specific chemicals health effects, technology and control systems of regulatory actions. **J4**	Using chemical industry model, evaluate alternative manufacturing methods to reduce product(s) contamination and waste emissions from processing steps. **J5**	Design and implement a program for use of generic and alternate processes approaches by regions. **J6**

Dirty air can cause disease.
EPA's research helps to maintain
good air quality.

Each year over 200 million tons of harmful gases and particles pollute America's air. Yet, were it not for the development and deployment of the technologies that control emissions of air pollutants we would experience far dirtier air. However, some of the control techniques may need to be improved. For example, fine particulates which may cause lung damage are not perceptibly kept from the air by application of conventional devices. And in the future we may see increases in the net amount of pollutants emitted to the air if continued industrial growth is not matched by concurrent advances in process and control technology.

Toxic air pollution may cause cancer, mutation, or birth defects.

Air pollution can cause or contribute to the chronic diseases of asthma, emphysema, bronchitis, lung cancer, leukemia, and heart disease. Toxic air pollution may cause cancer, mutation, or birth defects. Those who suffer from these effects of air pollution need not live near the source of that pollution, for pollution plumes can be transported great distances. People and the environment far downwind can feel the impacts of the original pollutants or some new pollution products created by chemical combinations, reactions, and subsequent transformation of the many substances in the atmosphere we must breathe.

Approach to Protect the Public Health and Welfare

The Clean Air Act provides the legal tools to control air pollution. Under the act, EPA is directed to set ambient air quality standards that protect the public health (primary standards) and welfare (secondary standards). These primary and secondary standards are established for pollutants emitted by either stationary or mobile sources. Standards were originally set for particulate matter, SO_2, CO, hydrocarbons, NO_2, and total oxidants; a later standard was adopted for lead and a standard for ozone replaced the total oxidant standard. Every five years EPA reviews the criteria on which these standards are based and determines if revisions are necessary.

EPA is also responsible for limiting emissions of air pollutants that are hazardous to human health. Currently, hazardous air pollutant regulations exist for asbestos, beryllium, mercury, and vinyl chloride; regulations for benzene are under development. Under investigation are many other chemicals, primarily potential carcinogens, to determine whether they present a significant risk to the public. EPA will develop emission regulations for major sources of those hazardous materials which are shown to be dangerous.

We will also continue to emphasize national emission standards for new or modified stationary pollution sources as well as control of mobile sources including diesel cars and trucks.

Meeting the EPA standards is a responsibility of each state through development and implementation of State Implementation Plans (SIPs). These SIPs limit emissions from existing sources, set timetables for compliance by air polluters and define monitoring procedures. But air pollution is a multi-state problem that cannot be controlled by unilateral action by any one state. Our evolving research approach therefore is to study air pollution control at the regional scale. Currently identified problem regions include:

Air pollution is a multi-state problem.

(a) The Northeast Corridor, which is densely populated and downwind of heavily industrialized areas;

(b) The Ohio River Valley, in which coal is intensively used but which consequently influences air in the eastern and northeastern states;

(c) The Sun Belt, which is currently undergoing rapid population growth and which may experience more coal combustion for power generation and industrial production;

(d) Southern California, which has unique problems of photochemical pollution created by a large mobile population and uncommon climatic conditions;

(e) The area east of the Rocky Mountain Region, which has an abundance of energy resources and presently has pristine air quality; and

(f) Northern states and Canada, which have the problem of acid precipitation.

Research to Help Abate Pollution

Sound scientific information is necessary to: 1) determine the adequacy of existing air quality standards, 2) establish new standards, and 3) devise methods for controlling air pollutants. EPA's air quality research program is designed to provide the requisite information in a timely manner. Our research program includes the study of health and environmental effects of air pollutants, the atmospheric transport and transformation of the pollutants, technologies to detect, measure, and control them, and the global significance of air pollution. We specifically focus on criteria pollutants, hazardous pollutants, particulates, and vehicle emissions. The research will stress projects to determine the health effects of air pollution. Coordinated studies will include animal toxicology investigations, clinical studies and epidemiological studies.

Criteria

The Clean Air Act Amendments of 1977 mandated that EPA review and, where appropriate, revise the National Ambient Air Quality Standards and the criteria upon which they are based. The review and possible revision is to be completed by the end of 1980; future reviews are to take place at five year intervals thereafter. Our health effects research program will provide a definitive data base for the review of ambient pollutant criteria as well as the revision of criteria documents, where appropriate. On the basis of such criteria reviews and revisions, the adequacy of ambient standards can, in turn, be effectively reviewed. The next round of criteria and standards review, scheduled for the mid 1980's, will draw, in part, on data developed from our animal toxicology studies, clinical studies, and epidemiology. (A1 through A7)

In the toxicology studies animal models will be developed to simulate stressed individuals and to obtain dose-response data for air pollution doses at or near the current standards. Such studies optimize the relationship between animal and human response data and thus provide our best understanding of the damage air pollutants can inflict on pulmonary functions and other vital processes. The studies can also provide guidance for clinical and epidemiological studies. (A10, A12 through A15, A18 through A24)

Carefully controlled clinical laboratory studies will obtain human dose-response data using healthy volunteer male subjects. Data will be obtained under normal conditions and under stressful temperature and exercise conditions. As with the animal studies, exposures will be at and near the current standard levels for pollutants either alone or in combination, e.g., ozone and SO_2. Similar exposure studies will be conducted on volunteers who suffer from various afflictions, e.g., asthma, emphysema, and bronchitis. (A8, A9, A11, A17, A25)

> The new approach focuses on control of atmospheric carcinogens.

Epidemiological studies will concentrate on those regions in which the current air quality standards are exceeded. These studies will determine whether the health of the populace in the poorer air regions varies significantly from the health of those living in the better air areas. Many of these studies are planned for completion in 1983, in time for the next evaluation of the air quality standards due during the 1983-1985 period. (A16, A26)

Hazardous Pollutants

EPA has recently developed and plans to implement a systematic approach for regulating toxic air pollutants. The new approach focuses on control of atmospheric carcinogens.

Currently we are screening a large number of organic chemicals to estimate their potential as human carcinogens and the rate at which people are exposed to them at current patterns of emissions. From this screening we estimate that about forty chemicals per year will be selected for a detailed evaluation and approximately six per year may be selected for regulation if the detailed evaluations suggest a significant degree of risk and cancer incidence.

ORD's basic support activities will include verification of emission factors, field verification of exposure estimates, development of monitoring devices for regulatory enforcement purposes, determination of transformation rates in the atmosphere, verification of the efficiency and development of control devices, and verification of costs of control systems.

The air industrial program will undertake over fifty projects during the next few years to support development of various control standards for a broad range of industrial categories. The studies will range from generic and specific control technology development, process modification, and product substitution, to changes in operating practices of industries.

We will also better identify potential carcinogens and determine whether they occur at significant concentrations in ambient air in order to decrease uncertainties about exposure risks. This risk data will provide direct support to regulatory decisions based on risk assessments. Our hazardous pollutants research will also describe non-carcinogenic health effects.

Hazardous air pollutants emitted because of brief control equipment malfunctions and the resulting health effects are of concern to EPA's Office of Enforcement. That Office needs better information about the consequences of enforcement decisions which either shut down a source temporarily out of compliance with standards or allow it to continue to operate and pollute while control equipment repairs are being made. The information that ORD plans to provide to the Office of Enforcement will come from development and evaluation of continuous monitors for chemicals for which regulations are imminent.

Identification of Potential Carcinogens. The early identification and characterization of hazardous substances is of prime interest to EPA. To minimize the time needed to characterize potentially hazardous substances, a research program for the development of rapid screening techniques has been initiated. Currently, animal screens require 2 to 3 years to evaluate the toxicity of a substance; however, new techniques promise to reduce the time to 12 to 18 months. Other screens using bacteria, human and animal cells, plants, and fruit flies are being evaluated, and, if they can be developed into a reliable battery of tests, will further reduce the time and money needed for evaluation of a substance. Existing tests are being used to prioritize substances for further testing. (B11)

Chemicals will enter the regulatory process in a sequence based on our estimates of the potential danger.

Our initial screening of these methods to determine their capabilities to identify chemicals, indicate mutagenic activity, and determine biological effects will be completed shortly. A major field study to characterize hazardous pollutants in ambient air will then be initiated. The main study results will be a list of the airborne chemicals with high biological activity. These chemicals will enter the regulatory process in a sequence based on our estimates of the potential danger. (B1, B2, B7, B8)

Improved Risk Estimates. To improve our ability to estimate risk resulting from exposure to carcinogens, we will emphasize three research areas: *in vitro* studies, animal toxicology studies, and epidemiological studies of occupational groups and general populations. Animal models will be developed for assessing carcinogenicity of air pollutants; epidemiological studies will be conducted in those areas where high levels of air pollution and high rates of genetic diseases are known to coexist. Studies will also be undertaken to assess how air pollution exposures contribute to adverse health effects in persons who are exposed to pollutants that arrive via multiple routes. We will improve statistical techniques for handling data from morbidity and mortality studies and will also develop and standardize measurement methods and personal monitors to provide better dose-response measurements for both clinical and epidemiological studies. (B3, B9, B10, B12 through B15)

Control Technology Development. Our control technology research will cover a wide range of activities including fundamental studies, generic and specific control technology development, economic evaluations, process changes, product substitution, and maintenance and operating practices. As part of our research program we will develop technologies for controlling harmful toxic emissions and will also quantify any induced pollution effects from the control devices. The requisite information will come from characterization and assessment studies. We will emphasize control of volatile organic compounds, since they are the predominant class of chemicals identified with carcinogenic activity; their control can also help the atmosphere. (B16 through B19, J1 through J4)

We will emphasize control of volatile organic compounds.

Non-Carcinogenic Effects Associated with Chronic Low Level Exposures. The major portion of ORD's near-term air pollution health effects research will be to control carcinogens. But to limit ourselves to only carcinogenic effects would be short-sighted; therefore, we will devote some similar research efforts (albeit at a lower level of funding) to non-carcinogenic effects. *In vitro* screening and animal toxicology testing of ambient air samples will be carried out. Epidemiological studies will be completed in areas of known high disease rates to identify chemicals which cause significant adverse health effects. These data will be used to define risks associated with exposure to non-carcinogenic air pollutants. (B4, B5, B6)

Long Range Transport and Transformation

Past pollution research projects were generally laboratory studies and relatively small scale field studies. But as our understanding of the problems has deepened, our research perspective has shifted and we now realize the necessity of viewing air pollution on a regional scale. Findings from European and U.S. studies on pollutant transport and transformation, in particular, have led us to shift the current research approach to emphasize the regional scale. Our long-term research and development plans in air quality characterization, transport, and transformation have thus moved from the city-specific urban scale to state and interstate problems.

Consideration of the interstate transport problem is required of State Implementation Plans (SIPs) as part of the effort to:

- achieve acceptable levels of ozone, PM, and NO_2;
- prevent significant air quality deterioration; and
- assure good visibility

In many areas, O_3 and sulfate from distant upwind sources contribute significantly to local ozone and PM burdens; other pollutants may also be subject to long-range transport. Furthermore, reactive air substances from upwind sources may cause locally emitted pollutants to more rapidly form secondary pollutants, sulfate, O_3, and NO_2.

The long range transport and transformation research is designed to provide the basis for developing models to predict the reduction of these regional effects through the applications of control strategies. The pacing items in development of long range transport models are available and reliable mathematical constants to characterize processes and adequate data from experimental measurements with which to evaluate the accuracy of the models. Our research program will measure the key parameters which characterize transformation, wet and dry deposition, dispersion, and transport and will obtain a data base of meteorological and air quality information to test final model outputs and various modules of air quality models.

Model development is usually complemented by field measurements. Such measurements are designed to test specific models or model components and to compare model predictions with real data. This interactive process will produce models better able to represent and predict actual events.

Our model development/field measurement efforts will emphasize:

- Determination of model parameters such as meteorological transport and dispersion factors, chemical transformation rates, and removal rates;
- Collection of field data to improve and validate models for power plant plumes, urban plumes, regional pollution, and prolonged elevated pollution episodes and visibility impairment;
- Validation of models that determine transport of air pollution between the United States and Canada; and
- Documentation of the significance of the long range transport of air pollutants and the significance of formation of secondary air pollutants during transport as such formation applies to pollutants, acid rain, and regional visibility reduction.

One effort that is designed to achieve the above objectives is the STATE (Sulfur Transport and Transformation in the Environment) program. Under this program a series of specific field studies will be conducted to ascertain the individual and combined impacts of power plant plumes, and urban and regional-scale pollution. Air quality data from STATE will be obtained on key air pollutants such as ozone, sulfates, and nitrates. With these data we will assess the capabilities of air pollutants to produce wide scale visibility impairment during prolonged elevated pollution episodes which frequently occur in the summer and early fall. (C2, C7)

We will assess the capabilities of air pollutants to produce wide scale visibility impairment.

We are also developing a regional-scale photochemical air quality simulation model to help us determine the environmental significance of the transport of ozone and its precursors over long distances. The model will allow decision makers to better evaluate the impact of local oxidant control plans on surrounding regions and will provide an opportunity to assess the regional approach to oxidant control planning. This regional scale modeling program is designed to permit model development, refinement, evaluation, and verification and to provide a framework from which model research and development can evolve to meet future regulatory requirements. A field measurement program will evaluate, refine, and verify our first generation regional photochemical air quality simulation model. The field studies will focus on a series of experiments designed to evaluate and refine formulations of specific physical/chemical phenomena. (C3, C6, C9, C11)

We will also begin the development of an aerosol module for the regional model. Emphasis will be on the long range transport of fine/inhalable particulates to an area east of Columbus, Ohio and north of Richmond, Virginia. A first generation regional fine/

inhalable particulate model will be available in early FY 82, development of a visibility module for incorporation in the regional scale fine particulate model is planned to begin in FY 82, and a regional visibility model for the eastern United States will be available in late FY 83. Throughout these efforts, model evaluation and testing will be undertaken using field data. (C8)

Another current project is our three-year Northeast Regional Oxidant Study (NEROS) which has as its primary objective the evaluation and verification of a regional model and its subcomponents. Ultimately, however, the objective of NEROS is to apply the model to assess the impact of oxidant control plans on ozone transported from one urban center to another. The regional model will be available and sufficiently verified to warrant application in 1982 SIP revisions if emission inventories are provided for urban areas located in the Northeastern Corridor (i.e., from Baltimore-Washington to Boston). This model may be extended west in FY 82/83 to include the Ohio Valley region. (C1, C5)

Further experimental study of photochemical pollution/precursor transport phenomena and continued refinement of our regional model will be tentatively planned for the Sun Belt area during FY 82 through FY 85. This new experiment on air transport and transformation has as one of its primary objectives the study and development of modeling approaches for complex air flows introduced by land-sea interaction. Large urban and industrial complexes in the area will be studied and modeled to determine their contribution to the long range transport of photochemical pollutants and precursors. (C12)

The demand for improved air quality has increased.

Modeling to Predict Diffusion Over Complex Terrain. The demand for improved air quality has increased but so too has industrial and economic development, especially in mountainous regions. These counterpoints underscore the need for methods to intelligently site pollution sources and test ambient air quality. Research needed to make the siting decisions has lagged, however, due to the high cost of extensive field data for model development. This situation has become particularly critical for atmospheric dispersion data in areas of complex terrain where transport and diffusion processes are extremely complicated.

To deal with this problem, EPA has mounted a major research effort that will significantly improve the reliability of models of air pollution dispersion from large sources in complex terrain. A July 1979 workshop generated a set of program recommendations, which are being reviewed and implemented. The workshop concluded that one of the most pressing complex terrain modeling problems is the calculation of "ground-level" concentrations when a stable plume encounters a terrain obstacle. The workshop recommended that model development focus on isolated, simple terrain obstacles. As the program develops we expect to expand the types of plume configurations and terrain complexity that are modeled. We also intend to address the statistical problem of the probability that a plume will be transported to the vicinity of certain terrain obstacles. Concurrently we will conduct scaled fluid modeling studies to further increase the analytical basis for model development. (D1, D2)

Acid Precipitation. Acid rain is caused by transport and transformation of air pollutants. The acidity comes from the accumulation of strong acids, H_2SO_4 and HNO_3, in falling raindrops. Power plants burning fossil fuels are a significant source of atmospheric SO_2, which is the precursor of H_2SO_4. However, currently there is not a good understanding of the relative significance of various sources of nitrogen oxide (precursors of HNO_3) such as power plants, lightning, and fertilizers.

Acid rain harms vegetation, accelerates weathering, corrodes and degrades construction materials, increases the acidity of surface waters, and can kill sensitive biota in lakes, either directly or indirectly by accelerating leaching of toxic materials into the water. The impact of acid rain on the aquatic ecosystem can be especially severe in poorly buffered impoundments and streams.

President Carter recently established a ten-year comprehensive Federal Acid Rain Assessment Program to be planned and managed by a Standing Acid Rain Coordinating Committee. As part of this program, EPA will determine the present and future degree to which acid precipitation will affect water quality and impair forest and crop production. In addition, to better devise control plans, EPA will study the basic mechanisms of acid precipitation formation. The ability to design these control plans also depends upon developing an understanding of recovery rates and mechanisms (i.e., in what way and how quickly can we de-acidify water systems?). The approach to support these information needs will be to establish a permanent monitoring network to routinely collect data about the chemical composition of precipitation, the significant sources of precursors and transformation pathways of pollutants, the atmospheric dispersion, transformations, net pollutant removal, and the nature and magnitude of ecological disturbances to agricultural land, forested land, range lands, urban land, and surface waters in the United States. (E1 through E14)

EPA will study the basic mechanisms of acid precipitation formation.

Particulate Matter Research

Fine particles (particles and aerosols with diameters below 2.5μm) can be emitted directly from combustion sources, or can be formed in the atmosphere from gases and vapors there. The gases and vapors can undergo both rapid reactions near the sources (SO_3 to H_2SO_4) or slower reactions well downwind of the originating sources to form various sulfates, ammonium nitrate and organic aerosols (SO_2 to sulfate, NO to nitrate; higher molecular weight organic vapors to organic aerosols). Particles containing metallic elements in this size range represent direct particle emissions (lead aerosol, vanadyl sulfates and other vanadium salts, zinc salts); other particles in this same size range are also predominantly from anthropogenic sources. The quantity of directly emitted particles compared with the amount generated in the atmosphere is inadequately defined. It is important to quantify these contributions to optimize emission control strategies.

Particles larger than 2.5μm diameter are formed mainly by mechanical processes in industrial activities, by resuspension of dusts in urban areas (construction activities, street dusts), and by natural processes and agricultural activity. For control strategy purposes, it is important to determine whether particles in this range originate from anthropogenic or natural sources.

Airborne particles cause or contribute to adverse health effects as well as welfare effects such as visibility degradation and soiling. Recent research has indicated that adverse health effects from particles are associated with the smaller size fractions, especially those particles with an aerodynamic diameter of less than 15μm because they penetrate the upper respiratory system. The EPA Fine Particulate Research Program is directed mainly at particles less than 15 μm in diameter. (F1 through F16)

The major research in the area of fine particulates characterization includes:

- The characterization of source emission and ambient aerosols (size, distribution, amount, composition, mass, etc.);
- The determination of the health, ecological, and visibility effects both alone and in combination with other substances found in the air;
- The determination of the mechanisms, rates, and products of conversion of gaseous pollutants to fine particulates;
- The determination of the relative contribution of different sources to ambient fine particulate concentrations;

- The development of methods to relate sources of pollution to the ambient levels of particles;
- The development of methods to allow the design of strategies to reduce the ambient particles to an acceptable concentration; and
- The development of instrumentation needed to measure particles by size and chemical composition and to assure that the resulting regulations can be enforced.

In addition to particulates characterization, our research will develop data for particulates control.

The research to control particulates to keep them out of the air will be in three main areas: 1) control of sulfate particles by SO_2 control; 2) control of nitrate precursors by NO_x control; and 3) direct control of particulate emissions including particles less than $2.5\mu m$ in diameter. (F20 through F23)

This work will help with development of a rational control strategy that is based on the functional relationship between the ambient air aerosol distributions and concentrations and the emission sources of particles and precursor gases. Understanding such relationships is essential to the development of effective and enforceable SIPs. The relationship depends on the emission rates of the sources, chemical reactions and physical processes which convert gases and vapors to aerosols, terrain conditions, meteorological parameters, weather patterns, and rates of dry and wet deposition.

The research program will emphasize laboratory and chamber measurements.

As part of our support for the development of these critical relationships, the research program will emphasize laboratory and chamber measurements to identify the most important chemical and physical processes and mechanisms. The work will include direct field measurements to obtain data on the interaction between chemical-physical-meteorological parameters for rates of formation, dispersion, transport, and deposition.

Increased control efficiencies of conventional particulate sources required by emissions regulations will also be supported by our research. Such support will be derived from evaluations of existing techniques and devices to determine their possible use at higher efficiency levels and from evaluations of control device modifications to delineate their suitability for operation under more adverse conditions or on untried but essential future applications. The progression of our work will be to: field test suitability of existing devices; test modified devices in laboratory pilot and field configurations; and finally, complete our engineering evaluations of modified or newly applied devices on a scale large enough for setting standards and for evaluating cost performance.

We will identify, evaluate, and develop important advances in control technology.

The research will also emphasize the evaluation of new particle control technology that may significantly reduce equipment size, increase removal efficiency, and potentially apply to previously uncontrolled sources. We will identify, evaluate, and develop important advances in control technology. Pilot scale demonstrations will be conducted for fine particulate collection systems at industrial sources. Such industrial sources include coal strip mine haul roads, iron and steel plants, and small coal consuming energy sources. Specific projects include investigation of magnetic separation of fine particles in the iron and steel industry, development of strategies and methods for fugitive emission control, and study of electrostatic enhancement of fabric filters.

Implementation of these programs and others will depend on the availability of adequate sampling and analysis techniques. Despite past progress, the identification and verification of sampling devices that provide a sharp, reliable particle separation at 15 μm is not complete. We will therefore continue to work to develop measurement techniques and instrumentation for sampling and analysis of particulate sources and particulates in ambient air.

Inhalable Particulate Network (IPN). The present health based ambient standard for particulate matter (PM) (also referred to as Total Suspended Particulates) is not size specific. However, particles of greatest concern are those which can be inhaled into the respiratory system. We have identified those particles smaller than 15 μm (aerodynamic diameter) as most likely to be responsible for human health effects. Other considerations motivating our research and the review of PM criteria include ongoing litigation over review and revision of the criteria document, and recent data which show that more than 400 areas in the United States currently do not meet the ambient standards.

Particles of greatest concern are those which can be inhaled into the respiratory system.

To help revise the standards, if necessary, and to help prepare control strategies, we must first identify what portion of suspended particulate matter consists of inhalable particulates (IPs). An inhalable particulate network will supply us this important information. The first phase of the network, already in place, consists of nearly 100 sampling stations at selected sites across the United States. Sites given preference were those locations with an on-going or historical health studies data base. Samples will provide data to identify mass ratios and will help determine localized source influences by analysis of samples. The distribution of these measurements across selected metropolitan areas will be determined as will an indication of the impact of localized source contributions.

The data collected from the IPN can also be used for:

- comparison with existing PM measurements from other samplers including the hi-vol and the British smoke shade sampler;
- relating health effects to control strategies; and
- support for planning if the standard is revised.

We must also ensure data accuracy; therefore, sampler reproducibility data will also be collected. (F17, F18, F19)

Visibility. An analysis of visibility measurements at selected national weather stations shows decreasing visibility over the last 25 years. Visibility decrease can be correlated with SO_2 emissions and with ambient concentrations of sulfate and other components of total suspended particulate matter. Observed improvements in visibility in the West during the last five years appear to have been associated with decreases in SO_2 emissions from smelters.

The visual quality of air is readily perceived by the public. Better visibility is desirable for aesthetic purposes. But good visibility may also provide a degree of public health protection because some of the visibility degrading particles are the same as those which cause health problems. We expect to derive some needed information about visibility degrading particles from other projects which will study inhalable particles. For example, ambient air samples from the projects will determine concentrations of particles less than 15 μm and 2.5 μm in diameter, and control technology will be investigated for application to particles in the same size ranges.

EPA is mandated to regulate air pollution to protect visual quality. To provide the scientific basis for this mandate, we will quantify the physico-chemical nature of visibility degrading aerosols for urban and rural areas.

We will also develop acceptable measurement methods and air quality simulation models to establish the relationship between ambient air observations and pollution sources.

We will conduct field investigations of visibility in the eastern states to characterize the contribution of urban and rural aerosols to visibility reduction. The urban studies will attempt to measure three-dimensional pollutant profiles in the urban zone and in the urban plume. This data will be used to characterize aerosols and to validate air quality simulation models that relate visual quality to emissions. These urban studies will be carried out in three types of eastern cities: predominantly heavy industry, mixture of heavy and light industry, and predominantly non-industrial. The rural studies, on the other hand, will attempt to determine the atmospheric aerosol extinction budget, and the contribution of sulfate, nitrate, carbon, and minerals to aerosol light scattering/absorption as a function of aerosol diameter. We will also determine if the relationship between aerosol light scattering/absorption and fine mass concentration can be used as equivalent indicators of visual quality. (G3, G6, G7)

Better visibility is desirable for aesthetic purposes.

We are particularly concerned about visibility in pristine areas (Class I areas). Our work will analyze existing information on visibility conditions and trends, determine appropriate instruments for measuring visibility, establish a monitoring network in Class I areas, determine sources of visibility aerosols, develop plume blight and regional haze models, obtain field data to evaluate and improve models, and provide validated models. (G1, G2, G4, G5)

The results of this work are expected to predict the impact of new and existing sources of pollution on visual air quality in urban and pristine areas.

Vehicle Particulate Emission—A New Variation on an Old Problem

For many years passenger cars and trucks have been important sources of ambient air particles, and they continue to contribute most of the finely dispersed lead aerosol, some elemental carbon, and the organic matter associated with the carbon. In recent years, about 10 percent of the fine particles in the air have come from these transportation sources.

Catalytic control systems for passenger cars and EPA rules phasing lead alkyl antiknock compounds out of gasoline are markedly reducing the total contribution of mobile sources to ambient air particulates. In 1977, these pollutants were down 30 percent from the all-time high in 1974. Still lower levels are projected through 1983. However, the introduction of diesel engines in passenger cars and an increased number of diesel urban trucks threatens to considerably increase vehicle-produced particle emissions in years following 1985. Current projections suggest that by the year 2000 atmospheric particulate material from the diesels and other vehicles could be double the amount emitted in 1977.

Over the past five years, ORD has developed information and measurement methods for developing regulations that limit vehicular particulate emissions. We are now pursuing an assessment of technology to control diesel emissions from exhaust systems. ORD data have played a part in EPA's development of regulations covering diesel passenger cars. Regulations for heavy duty trucks will be promulgated afterward.

Diesel Emission Health Effects. Evidence of mutagenic chemicals in diesel exhaust particles has recently been found. These chemicals are structurally related to polynuclear aromatic hydrocarbons which are known carcinogens. But overall mutagenic activity that has been caused by the organic materials in diesel particles is higher than can be explained by the minor amounts of polynuclear aromatic hydrocarbons (PAHs) present. Either the concentration or the potency of these chemicals must be greater than the PAHs in diesel exhaust particles. In either case, the presence of these hazardous chemicals may not be best addressed by regulations limiting the mass emissions rate of particles. Consequently, ORD's research will gather data that will determine the need for regulation above and beyond particle mass emissions standards.

The ORD program gives high priority to the analysis of the possible health risk American people face from diesels. Our preliminary risk assessments, using admittedly fairly crude assumptions about exposure and potency, suggest a significant risk of cancer from exposure to diesel soot. We will therefore quantify expected public exposures to diesels and will study the effects on human health of exposure to diesel particles. To this end, a major effort will produce data about the comparative potency of different types of particulates to produce cancerous tumors in animals and in other biological test systems. This effort will compare the tumor-causing potency of organic extracts from diesel soot and other combustion aerosols to organics from coke ovens, roofing tar, and cigarette smoke condensate. Human epidemiological data available for these latter materials will aid in the comparison. (H5, H7, H13)

We will therefore quantify public exposures to diesels.

The health effects research program uses a battery of tests run in parallel to develop cancer dose-response data in whole animal experiments and in tissue culture systems. A number of test systems are being used because comparative potency risk assessments obtained from any single system alone may be too uncertain for effective use. Tests being conducted include both short-term mutation and carcinogenesis of bioassays. Such tests will provide semi-quantitative information needed for predicting expected mechanisms and responses in whole animal testing. The most quantitative data available, however, comes from whole animal skin-painting experiments. Intratracheal instillations will provide information on the cancer potency of extracts in the critical exposure area, the lung, while whole animal/whole exhaust inhalation experiments may provide "yes or no" information on the capacity of diesel exhaust to cause lung tumors. These experiments might also indicate whether exposure to diesel exhaust could predispose people to adverse health effects such as pulmonary fibrosis or emphysema. (H6, H10, H14, H15)

Atmospheric concentrations of particulates estimated from several time scenarios of diesel market penetration and pollution control measures have already been calculated from available particulate organics emissions factors and meteorologic models for St. Louis, Kansas City and other cities. Similar estimates for other cities are being calculated from models that use ambient air lead as a surrogate for particulate material. Other modeling techniques will be employed to estimate maximum and average exposures received by commuters so we can estimate the number of people exposed to various concentration levels of diesel particles. This information and the comparative carcinogenic potency data will be factored into risk assessment models. (H4, H12)

Characterization Research. Our characterization research is best defined as the process to identify and measure the diesel emissions of interest from a variety of sources under different operating scenarios. This characterization research will help answer certain questions regarding control of mutagen diesel emissions, questions associated with comparison of other combustion sources, gasoline and synthetic fuels, and with strategies for control. For example, a key control strategy question deals with where and when regulation might achieve the most health benefits while causing the least economic disruption.

We will concentrate on improving exposure estimation techniques. This work will include direct measurement of exposure to diesel mutagens at the New York City Port Authority Bus Terminal. Smog chamber experiments will be used to estimate the impact of photochemical conversion on the mutagen organics. (H2, H3)

At present, only crude semi-quantitative measurement methods are available for the mutagen organics in the particulates and no methods have yet been developed to collect gas phase hydrocarbon for bioassay tests. But even with the existing techniques a survey of a large number of sources under variable conditions would be extremely expensive. Further compounding this problem is the fact that a number of control systems or alternatives are to be assessed. To rectify this situation, we will initiate in FY80 a substantial effort to develop very simple, inexpensive measurement techniques. This work will concentrate on methods to collect gas phase samples and to identify the compounds which produce mutagenic activity and on discovering a rapid, effective chemical means to measure them. Until such methods are available, however, measurement of mutagen emissions from a variety of sources will continue using existing procedures.

Continued basic and applied studies will investigate the effect of fuel type.

Recent studies have also demonstrated the importance of the type of diesel fuel in the generation of mutagenic emissions. Continued basic and applied studies will investigate the effect of fuel type. One study using pure hydrocarbon fuels may produce information to help us understand the formation chemistry of these compounds and, therefore, the most efficient means of control.

While the prime thrust of the scheduled research is the evaluation of vehicles as sources of particle mutagens, we will continue to conduct some comparable studies using a few stationary sources such as oil-fired residential furnaces. Using the techniques developed for diesel engine research, attempts will be made to determine the rate at which these sources emit mutagenic material. (H1)

Past regulation research support is a continuing requirement to ensure proper EPA regulatory decisions. Characterization of diesel emissions will be needed in FY82 and beyond for new fuel-efficient prototypes of future automobiles. However, current information on the prospect for mutagen control is virtually nonexistent. Also, there are some vast differences in emissions from currently uncontrolled vehicles. Therefore, for FY81 and beyond ORD will continue to provide EPA's Office of Air, Noise, and Radiation with information about combustion sources of mutagen organics. As part of this research, various emission control devices are scheduled for testing and development. (H9, H11)

To directly support the regulatory responsibilities of the Office of Air, Noise, and Radiation, ORD has scheduled improved health risk and control technology assessments for FY80 and 81. Follow-on support for regulation development after FY81 is suggested by past similar mobile source problem areas. As new information relative to the emissions of specific mutagenic compounds becomes available, this follow-on work will include additional health effects experiments to study the relationships between whole extract and compound potency with the ultimate goal of improving the risk assessment process and expanding information on acceptable risks. (H8)

Global

Man's activities have caused vast increases in atmospheric concentrations of a large number of contaminants including hydrocarbons, halocarbons, and carbon dioxide. These materials are expected to have deleterious effects on air quality, climate, and stratospheric ozone.

Global atmospheric research studies performed and funded by EPA have centered on halocarbon reactivity and persistence and ozone produced from hydrocarbon emissions. Other research to understand the global effects of CO_2 emissions is being conducted by the Department of Energy. (I1 through I5)

Halocarbons. The tropospheric persistence of many halocarbons permits their upward diffusion into the stratosphere. For highly halogenated chemicals, photolysis in the stratosphere is the primary atmospheric removal mechanism, but unfortunately, this process also leads to the destruction of the vital ozone layer in the earth's upper atmosphere. Depletion of the ozone layer would expose the earth's surface to short wavelength ultraviolet irradiation (UV-B). An increase of UV-B exposure would produce additional cases of human skin cancer and would likely have immediate detrimental effects on aquatic and terrestrial ecosystems. Halocarbons in the stratosphere can also cause temperature changes by altering the normal solar absorption of the stratosphere. This could result in serious climatic changes in the lower troposphere.

An increase of UV-B exposure would produce additional cases of human skin cancer.

Our halocarbon research program will continue efforts to characterize halogenated chemicals in the troposphere to determine the atmospheric burden, growth rate trends, and atmospheric residence times. We will perform field measurements as well as laboratory and modeling studies to improve our understanding of the reaction mechanisms and rates at which halocarbon chemicals react in the atmosphere and diffuse into the stratospheric ozone layer. These studies will attempt to identify halocarbon atmospheric reactions products such as phosgene, acid chlorides, and halogenated PAHs, which may pose a secondary hazard to human health and welfare.

Ozone. Other research will continue to study the poorly-understood exchange of stratospheric and tropospheric air masses. Past attempts to quantify stratospheric O_3 fluxes to the troposphere have not been successful in predicting expected rural O_3 levels. Determination of the contribution of these fluxes to ambient O_3 levels is crucial to our understanding of interregional movement of ozone. Our studies will continue to refine the $^7Be/O_3$ ratio technique, a method which assumes minimal decay rates of ^7Be and O_3 from the stratosphere to ground level. Accurate ^7Be measurements can help determine the stratospheric contribution to ambient O_3 concentrations.

Welfare Effects. Welfare effects research is defined in Section 203(h) of the Clean Air Act to include effects on soil, water, crops, vegetation, animals, wildlife, etc., as well as effects on economic values, personal comfort and well being. EPA's process to set and review air quality standards requires that at least every five years the scientific data base on welfare effects be reviewed and updated where appropriate just as is done for the human health effects data base.

Future welfare effects research will more effectively address the issue of the significance of agricultural losses caused by air pollution. The work will include a comprehensive study of agricultural areas under the National Crop Loss Assessment Network. Normal crop culture conditions will be maintained under ambient and simulated regimes of known air pollution levels (ozone and SO_2) and subsequent reductions of crop growth, quality, and yield will be translated into economic losses which can be used to model predictions of national welfare effects impacts over a range of air quality scenarios. Resulting data will support the planned 1984 review and revision of SO_2 and O_3 air quality criteria documents. The data will also be useful to states for developing strategies to implement welfare standards; the data will also be of use to EPA for evaluating the adequacy of the state strategies.

Our research to determine the effects of air pollutants on structural components and functional processes of natural ecosystems will rely on long-term ecosystem field research. One project will study the ecosystem effects of graduated ambient concentrations of ozone in a mixed conifer forest ecosystem of southern California. A proposed study in the Appalachian Mountains of western Virginia will address the effects of ambient ozone concentrations on an eastern mixed deciduous forest. The purpose of these ecosystem studies is to develop correlations between oxidant dose and ecosystem response. Other welfare effects research covering visibility degradation and acid precipitation has been described earlier.

AIR RESEARCH PLAN

PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
CRITERIA					
Criteria Development	Criteria for six hazardous pollutants (each year). **A1**	continuing →			
	Complete SO particulates air quality criteria document. **A2**	Review pollutants associated with synfuels. **A4**	Review and revise lead air quality document. **A5**		Review and revise ozone air quality criteria document. **A6**
	Complete review of hydrocarbons. **A3**				
					Review of CO air quality criteria document. **A7**
Health Effects	Complete exposure chamber studies of the effects of nitrogen dioxide on healthy and asthmatic human subjects, with bronchial stress. **A8**	Complete exposure chamber studies of effects of ozone on healthy and impaired human subjects, exercise and heat/humidity stressed. **A11**	Complete exposure chamber studies on human subjects of threshold and stress studies on ozone, nitrogen dioxide and sulfur dioxide effects. **A17**		

PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
	Complete preliminary exposure chamber studies on human subjects of ozone effects at levels at and near existing air quality standards. **A9**	Complete examination of effects of O_3 and NO_2 on glucose—6 phosphate deficient animals. **A12**	Determine effects of NO_2 and O_3 alone and in combination on xenobiotic pharmacokinetics. **A18**		
	Complete studies on the effect of O_3 and NO_2 on protein leakage into the animal lung. **A10**	Determine effects of NO_2 and O_3 combinations using the pentobarbital induced sleeping time model. **A13**	Complete development of a lung immunology model. **A19**		
		Develop animal model systems to investigate the cardiovascular system and assess the effect of O_3 and NO_2 alone and in combination using these models. **A14**	Determine effects of O_3 and NO_2 combinations on lung anti-oxidant metabolism in young adult and aged animals. **A20**		
		Determine effects on O_3 on asthma mechanisms and lung pharmacology (prostaglandin E2 metabolism; thromboxanes; and histamines in animals. **A15**	Provide a model for extrapolation of effective concentrations of O_3 and NO_2 between animals and man. **A21**		
		Complete acute respiratory disease study in Los Angeles basin. **A16**	Determine effects of chronic exposure to a low baseline level of NO_2 on which are superimposed peaks of NO_2 on host defense mechanisms and pulmonary function. **A22**		
			Develop and utilize with O_3 and NO_2 additional cardiovascular animal models. Determine effects of O_3 and NO_2 alone and in combination on asthma mechanisms and lung pharmacology (PGE2 metabolism, thromboxanes, histamines, and angiotensin) in animals. **A23**		
			Determine susceptibility of young animals to O_3 and NO_2. **A24**		

AIR RESEARCH PLAN (CONT'D)

PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
			Develop and utilize (O_3 and NO_2) models of immunologically and pharmacoligically induced airway resistance. **A25**		
			Complete data analysis and report preparation for Texas Gulf Coast Asthma Study. **A26**		
HAZARDOUS POLLUTANTS					
Characterization and Assessment	Pilot study to characterize ambient air. **B1**	Characterize ambient air at one urban site. **B7**			
	Conduct field studies for 3 chemicals per year designated by OAQPS. **B2**				
	Provide guidance for mutagenic and teratogenic risk assessment. **B3**		Report on concentrations and transport and fate of halocarbons. **B8**		
	Develop model for assessment of chronic non-carcinogenic health effects. **B4**		Model validation		
	Evaluate interaction of metals with neural pathways. **B5**				
	Evaluate neurochemical indicators of hazardous pollutant exposure. **B6**				

PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
Health Effects	Select study sites and design studies of the effects of acute exposure to hazardous air pollutants. **B9**	Complete validation of short term techniques for screening and ranking effects of hazardous pollutants on host defense mechanisms. **B11**	Utilize the validated short term exposure technique to rank hazardous pollutants for lung toxicity. **B13**	Complete inhalation testing of the effects of several (at least 6) chemicals on host defense mechanisms. **B15**	
	Select study sites and design studies of effects of long term exposure to hazardous air pollutants. **B10**	Complete data collection for case control study of cancer in Contra Costa County California. **B12**	Complete concentration response inhalation studies of several arsenic compounds on host defense mechanisms. **B14**		
Control Technology		Complete evaluation of incinerator performance on acrylonitrile and ethylene dichloride process vent gases. **B16**	Assess, identify, and document VOC problems in the metal finishing industry. **B17**	Develop leak occurence frequency data and emission factors for synthetic organic chemical manufacturing facilities. **B18**	
				Demonstrate improved VOC capture systems for solvent evaporation operations. **B19**	
LONG RANGE TRANSPORT AND TRANSFORMATION	Conduct second phase of NEROS. **C1**	Results of NEROS. **C5**	Evaluate regional model with NEROS and PEPE data. **C7**		Validate regional model. **C11**
	Conduct first PEPE study. **C2**				
	Report on Tennessee Plume Study (TPS) **C3**	Evaluate reactive plume models with TPS data. **C6**	Results of Fine Inhaled Particulate Regional Modeling Study (FIRMS). **C8**	Validate reactive plume model. **C9**	
	Conduct first cold weather plume study. **C4**			Results of Northeast Visibility Experiment (NERVE). **C10**	Results of Gulf Coast Regional Experiment on Air Transport and Transformation. **C12**
COMPLEX TERRAIN	First field experiment completed (small hill study). **D1**		Product computerized model for application to selected complex terrain situations. **D2**		

AIR RESEARCH PLAN (CONT'D)

PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
ACID PRECIPITATION	Evaluate Euromap and other long-range transport models. **E1** Evaluate atmospheric acid deposition on lakes in northern Minnesota. **E2** Identify terrestrial ecosystems sensitive to acid deposition in the northeastern U.S. **E3**	Establish weekly sampling for core network of 40-50 stations nationally. (System will operate for 10 years with annual reporting.) **E4** Document geographic distribution of sensitive aquatic ecosystems and those exhibiting symptoms of acidification. **E5** Document different structural materials most prone to acid deposition. **E6**	Report on 3-year event sampling from regional network in northeastern U.S. **E7** Report on attempt to develop a practical measurement technique for dry deposition. **E8** Report on the effect of comlex meteorology on long-range transport. **E9** Report on effects of acid deposition on major U.S. crops and forests. **E10**	Report on results of manipulative studies of lakes involving intentional acidification. **E11** Report on weathering of materials based on controlled laboratory and field experiments. **E12**	Report on field studies to define the long-range transport of pollutants in the planetary boundary layers. **E13** Report relative damage associated with sulfates and nitrates. **E14**
PARTICLES **Health Effects**					
	Complete exposure chamber studies on normal human subjects of effects of single species of particulates. **F1**	Complete exposure chamber studies on humans of effects of combinations of sulfate and nitrate aerosols with ozone, nitrogen dioxide and sulfur dioxide. **F4**	Develop and validate an animal screening system for lung fibrosis and other lung diseases. **F9**	Complete human exposure studies of effects of significant pollutant mixtures on healthy subjects. **F10**	Complete human exposure chamber studies of effects of pollutant mixtures on at-risk populations. **F14**
	Initial report on effects of particulate air pollution on asthmatics (Denver). **F2**	Determine acute and intermittent effects of $(NH_4)_2SO_4$, NH_4HSO_4 and NH_4NO_3 in normal and impaired (emphysema) animals. **F5**		Determine the effect of long term exposure to SO_2 and carbon, alone and in combination on the pulmonary and systematic immune system. **F12**	Determine chronic effects of a combination of a fine mode pollutant and a gas in normal and impaired (emphysema) animals. **F15**

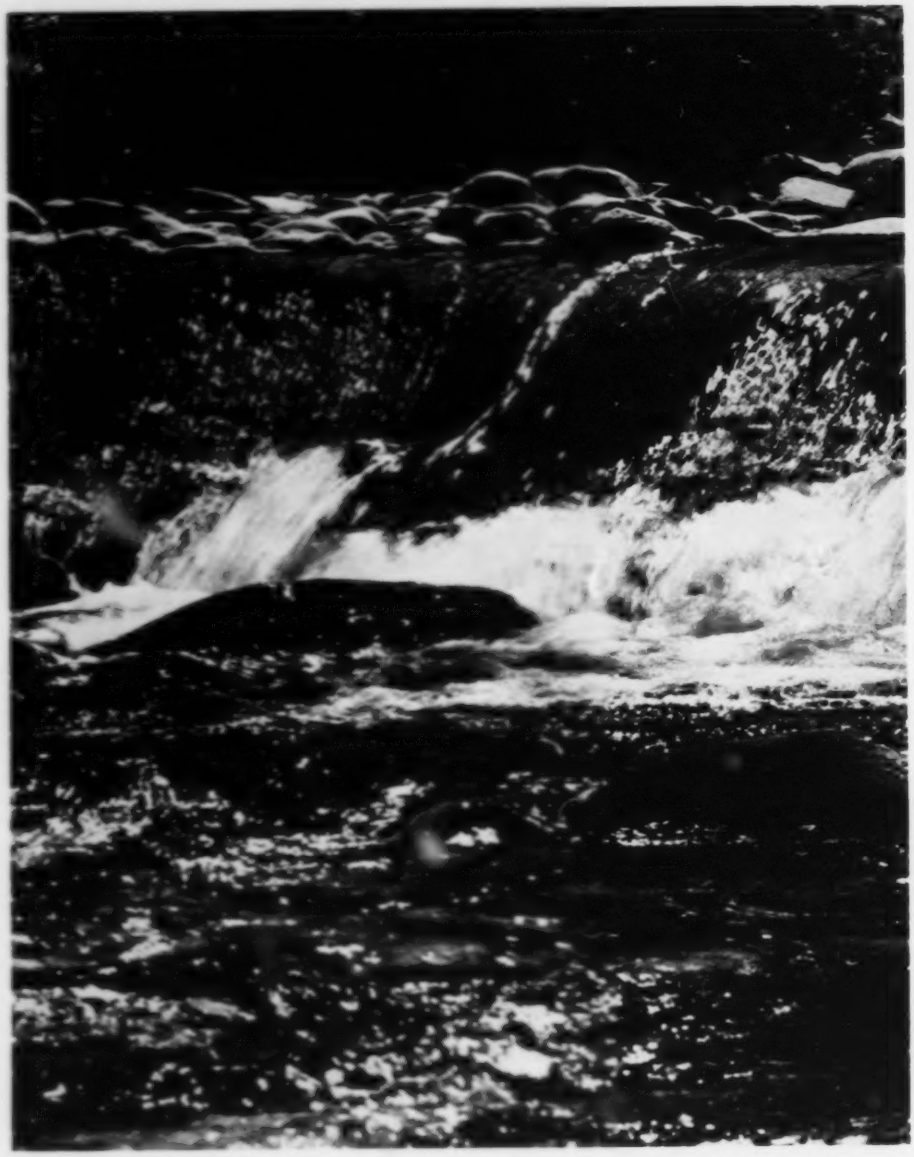
PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
	Prepare report on studies of particulate air pollution and human health effect. **F3**	Develop and test an animal model for effect of pollutants on viral disease. **F6**		Determine the effect of complex pollutant mixtures (including oxidants, organics, sulfur species) on host defense mechanisms and pulmonary function. **F13**	Synthesis of animal and human initial deposition data into a model to relate exposure conditions used in animal studies with comparable exposures of humans that would likely be necessary to produce similar biological effects. **F16**
		For commonly used laboratory animals, determine regional deposition curves as a function of particle size. **F7**			
		Complete inhaled particle epidemiology problem definition study. **F8**			
Monitoring	Establish an additional 100 IPN monitoring sites nationwide. **F17**	Establish final 100 IPN monitoring sites resulting in a total of 300 sites. **F18**	Assess continuing need for changes in IPN network. **F19**		
Control	Complete preliminary characterization of IP emissions to extend existing IP data base. **F20**	Final report on evaluation of new fine particle control technology. **F22**	Report on optimum wet scrubber operations. **F23**		
	Report on effect of electrostatic precipitation of fine particle control. **F21**				
VISIBILITY	Report on VISTTA-II field data. **G1**	Validate plume blight model. **G4**	Conduct field study on regional haze. **G6**		Report on validation of regional haze model. **G7**
	Analysis of VIEW data. **G2**				
	Report on field study in Northeast city. **G3**	Report on field study in Class I area. **G5**			

AIR RESEARCH PLAN (CONT'D)

PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
VEHICLE PARTICLES	Report on emission factors for particles, mutagens and harmful gases from diesel, catalyst and leaded gasoline fueled passenger cars. **H1**	Demonstrate particulate controil technology for diesel emissions. **H8**	Fuel effects and characterization of diesel ticulate emissions. **H11**	Final report on intratracheal instillation. **H15**	
	Report on diesel exhaust transformation products using smog chamber. **H2**	Characterize emissions from 6 trucks and buses. **H9**	Field study to determine population exposures to diesel emissions. **H12**		
	Final report on N.Y. bus terminal characterization study. **H3**				
	Trend reports to measure effects of increased diesel usage. **H4**	REPORT UPDATED EVERY SIX MONTHS →			
	Critical review of epidemiology studies. **H5**	Report on *in vivo* studies of carcinogenesis/mutagenesis. **H10**	Final report on epidemiology studies. **H13**		
	Report on *in vitro* studies. **H6**		Report on *in vitro* studies on non-carcinogenic toxic effects. **H14**		
	Report on risk assessment of diesel exhaust. **H7**	REPORT UPDATE		REPORT UPDATE	

PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
GLOBAL POLLUTION	Stratospheric O_3 intrusion measurements. **I1** Report on ambient levels and reactivities of terpenes. **I2** Report on presence of methyl chloroform and other halocarbons in the atmosphere. **I3** Develop and evaluate photochemical air simulation models for use in assessing the dispersion and impact of ozone and its precursors on air quality. **I5**		Report on fate and transport of halocarbons and carcinogenic halocarbons. **I4**		
CONTROL TECHNOLOGY		Complete evaluation of foreign basic oxygen furnace process secondary emission control. **J1**	Complete single compartment full scale demonstration of electric field fabric filter. **J2**	Transfer technology from high resistivity ESP (precharger) demonstration to commercial practice. **J3**	Issue final report on technical and economical feasibility and long term reliability of a fabric filter operating on a large utility boiler burning western low sulfur coal. **J4**

WATER QUALITY



Water is one of our most precious natural resources. EPA is working to understand water ecosystems and the consequences of water pollution.

The objective of EPA's water quality research program is to provide the assessment methods and information necessary to assist federal, state, and local governments in identifying their optimal water quality goals and in evolving cost-effective strategies for achieving those goals. The objectives of EPA's water quality management program are (1) to identify current and future water quality needs and goals; (2) to develop cost-effective strategies for maintaining and achieving water quality goals; and (3) to implement these strategies through orchestrated federal, state, and local participation.

Research to support these management program objectives is outlined in three chapters of this **Outlook:** this chapter, "Wastewater and Spills," and "Drinking Water." Taken together, these three chapters present a comprehensive view of ORD's research effort on all fronts of the nation's water pollution problem.

Water Pollution Sources

Water can be polluted in many ways; some are obvious, some subtle and complex. Most direct of the methods is *point source* pollution. Here, pollutants enter a body of water from one single point or source, such as an industrial waste discharge pipe. With point source pollution, it usually is a relatively simple matter to sample discharged material, then analyze it to determine the types and amounts of pollutants being released into the water.

Non-point source pollution data, however, is much harder to come by, mainly because its sources — runoff from agricultural fields, harvested timberlands, urban areas, and mines — are so diverse, widespread, and intermittent. These sources can be major pathways to water for toxic materials and polluting nutrients.

Most perplexing to researchers, however, is when pollutants transfer from one medium to another—*intermedia transfer*—refusing to respect science's artificially drawn "medium" lines. Substances often move from the air to the ground to the water and then sometimes back to the ground again in river and lake bottoms. When this happens, pollutants can accumulate as sediments or they can accumulate in the water's biota or move back again to the atmosphere through processes such as volatilization. Pollutants typically transferred from air to water include acids, metals, nutrients, PCBs, and DDT.

There are other major sources of physical, chemical, and biological degradation of water besides those just mentioned. These include poorly located or operated landfills, hydrologic modifications, such as channelization, impoundment, dredging, and spills of hazardous chemicals and oil. These, plus a host of others, result from human-generated activities.

> Pollutants typically transferred from air to water include acids, metals, and nutrients, PCBs, and DDT.

Growing Concerns

One of our foremost concerns in the area of water quality is the toxic potential of the chemicals that either exist in our waters and sediments now or may be released into them in the future. It is thought that the presence of some of these substances may lead to environmental damage or possible carcinogenic, mutagenic or teratogenic consequences. Today, tens of thousands of chemicals are in production; those that could present a water pollution threat probably exceed 10,000. As the chemical industry continues to grow, the potential for the release of toxic pollutants to the environment and subsequent water quality degradation increases.

While the provisions of the Toxic Substances Control Act are intended to protect the environment from much of this increase, the possibility of increased effluent or accidental discharge, as well as the ever-present danger posed to water quality by toxics in the air, continues to exist. We know, for example, that over 50 percent of the PCBs entering the upper Great Lakes comes from the atmosphere, and that these pollutants do not only have immediate effects while in the water column, but may also acutely affect aquatic life by entering the sediment, to be released at a later time, or by bioaccumulating in the food chain—on a potential path to man.

We remain concerned with the increased amounts of conventional pollutants and nutrients expected to be generated in the future. Although we have made considerable progress in controlling these conventional pollutants, our projections indicate increases in both point and non-point sources. Such increases could lead to plant and animal overgrowth in lakes, reservoirs, and estuaries, resulting in the depletion of oxygen and a number of other significant ecological changes. Phosphorus and nitrogen in rain and dry fall, for example, are significant sources of nutrients to large water bodies, but they may present a problem in streams, lakes, and estuaries, as have the non-point source phosphorus in the subestuaries of the Virginia section of Chesapeake Bay.

Over 50 percent of the PCBs entering the upper Great Lakes comes from the atmosphere.

Finally, we are concerned with the relationship between water resource management practices and surface and groundwater quality. Poor management of consumptive water may reduce the amount of water available to dilute incoming pollution loads, thereby making the water that is left of poorer quality, while other water misuse may add to the pollution loads to both surface and groundwaters. Seepage of irrigation waters from unlined canals, for example, can result in a 50 percent water loss, while other poor water management practices can produce irrigation return waters contaminated with salt and agricultural chemicals. In non-irrigated areas, changing land use causes alterations in the nature of the runoff which, in turn, affects concentrations of pollutants reaching surface and groundwaters.

Water Quality Management—Past and Future

Control of pollution at the source, through innovative technologies, has proven particularly effective for point sources of conventional pollutants. The major emphasis of the national water quality program over the past seven years, therefore, has been to base control requirements on such available technology, without a site-by-site assessment of water quality impacts. The controls were implemented for point sources through technology-based effluent limitations for industry and through secondary treatment requirements for municipal wastewater treatment plants. They, in turn, led to the concept of Best Management Practices (BMPs) for agriculture, silviculture, and other non-point sources. However, such control has not been proven broadly effective for such sources in terms of water quality improvements.

In the future, the technology-based controls of the past will, however, not achieve the water quality standards of the Clean Water Act in all areas of the nation. We thus anticipate an increased need for reliance on water quality-based management strategies. In addition, the nation's economic and energy problems will require that increased consideration be given to the cost effectiveness of pollution control measures. Our research plan reflects these viewpoints.

Criteria to support the Clean Water Act standards must be broadened to include an understanding of the physical, biological, and chemical ramifications of existing and anticipated water use. This is especially important in the development of future non-point source controls that must take into consideration the vast range of effects of a given pollutant in its various forms. We must also be able to realistically assess non-point control needs, and factor into water quality management the role of sediments as a source, a carrier, and pollutant sink.

The Research Plan

Our water quality research program is aimed at providing the tools and information necessary for making scientifically defensible, cost- and energy-effective pollution abatement decisions that will allow for the optimum use of water resources with minimum ecosystem impacts. Our program plan for the next five years is to concentrate on those technical areas that will help support decisions on:

- future water quality standards;
- water quality-based effluent limitations;
- second generation technology-based effluent guidelines;
- hydrologic modifications;
- innovative and alternative control technologies; and
- NPS management strategies.

Research attention will be given to:

- development of cost-effective techniques to measure and predict pollutant loads that enter or recycle within water systems;
- development of techniques to estimate and measure the distribution, concentration, and duration of pollutant exposures to humans and components of aquatic environments;
- development of techniques to predict the impacts of hydrologic modifications;
- assessment of pollution effects on humans and selected organisms within the aquatic environment;
- the response of aquatic systems to the stress of pollution; and
- development of energy-efficient and cost-effective control techniques.

The plan itself is structured around the current water quality goals set forth by Congress and around the information needs expressed by federal, state and local water resource managers to meet those goals. If, in the future, goals are modified or a serious gap in information emerges as our understanding of the problem deepens, our research plan will be modified accordingly. If a shift is made from achieving water quality goals through regulation to achieving them through incentives, our research plan will also be modified to identify and assess promising implementation strategies consistent with such an approach.

Scientific Basis for Water Quality Research

Each of our water quality research efforts is designed to fill gaps in knowledge essential for efficient future water quality management. Underlying this research is the belief that tomorrow's water management will require an even more comprehensive insight than does today's. We believe that in the future, individual water systems will have to be viewed as a part of a total ecosystem and that consideration will have to be given to simultaneous stresses from point sources, non-point sources, intermedia exchanges, and natural events. Relationships between water quantity and quality and between surface and groundwater quality will also have to be taken into account. Additionally, tomorrow's water manager must have up-to-date information on the state of the water ecosystem in order to predict the consequences of the multiple stresses being placed on it. The following descriptions of our research encompass these beliefs and the idea that to ensure water quality in the future, the right planning must be done today.

> Tomorrow's water manager must have up-to-date information.

Pollution Sources

Research to identify and characterize sources of pollution has three areas of emphasis: methods development, source characterization and measurement, and ambient water characterization.

Methods development refers to procedures to identify and measure specific pollutants in specific sources. Gaps in current methods, especially in such areas as organic chemicals, metals, and organo-metal compounds analysis, will be resolved through research directed at specific pollutants as well as broad classes of pollutants. (A1)

Narrow spectrum or single-chemical reference methods will be designed to measure specific toxic pollutants, especially those newly added to the priority pollutant list. This research is expected to assist National Pollution Discharge Elimination System (NPDES) permittees to self-monitor effluents. The reference methods will be designed with an eye toward a minimum amount of instrumentation, expertise, and cost. (A2, A7, A8, A9, A14, A19, A22).

Broad spectrum measurement methods will be developed to quantify a wide range of specific chemicals or classes of chemicals found in effluent discharges and ambient water samples. Although more complex than single-chemical methods, broad measurement methods will be particularly useful for scanning water to detect the presence of unanticipated compounds and for confirming the accuracy of self-monitoring results reported from a large number of samples from diverse sources.

A general guide for water sample analysis, or a master analytical scheme, will be developed to ensure consistent measurements of pollution. This guide will draw together and integrate recent advances in all areas of sample analysis, i.e., sampling, concentration, clean-up, and identification using GC/MS. Following testing, the guide will be applied — first to volatile organics, then, when separation techniques and liquid chromatography/mass spectrometry interfaces are improved, to non-volatile organics in water and wastewater, and finally, to sediments, sludges, and biological tissue. (A3, A4, A10, A26)

We will also develop surrogate or screening methods.

In addition to the guide, we will also develop surrogate or screening methods that can rapidly and inexpensively detect significant levels of toxic chemical classes in water. These methods will aid us in identifying toxic "hot spots" — areas that warrant more detailed qualitative and quantitative analysis. The use of such screening techniques will significantly reduce the cost and time required to analyze pollutant samples, thereby enabling us to allocate our resources faster and more effectively. (A11, A13, A15, A21)

We will also develop cost-effective analytical methods that accurately measure individual species of toxic metals, including species produced by reactions with chlorine and other disinfectants in water supplies. Since such methods are currently unavailable, measurements today must be made for total metal concentrations rather than for individual species of toxic metals. More refined methods will enhance the capability to measure only those chemical forms that are biologically available and on which water quality criteria are based. (A12, A18)

Source characterization and quantification involves providing a data base for use in estimating pollution loads from the four types of pollution sources: point, non-point, multimedia, and existing or background levels. Such research is vital because effective water quality controls can only grow out of a knowledge of the pollution sources and the synergism that exists between them.

Point source characterization and quantification is discussed in chapter 6, "Wastewater and Spills." Non-point source agricultural and urban pollution loads for selected pollutants can be estimated from models such as the NPS, ARM, and SWMM loading models, although many of them have not been verified. A greater gap exists in our understanding of pollutant loads from most other types of land use. Working with the U.S. Department of Agriculture (USDA), EPA's Office of Water Planning and Standards and others, we will do limited field testing and validation of selected methods for estimating the pollutant loads in runoff from different land uses.

Multimedia interrelationships will focus on transfers between the atmosphere and water and between water and sediment. In the near future, we will begin to quantify atmospheric contributions of certain alien biotic substances to each of the Great Lakes and to the Chesapeake Bay. Acid rain effects on the water quality of our northeastern lakes and streams and the resultant ecosystem stresses will also be characterized. (A5, A16, A17)

Ambient water characterization determines what pollutants already exist in a system. To make accurate determinations, we will have to develop a number of programs and methods. An integrated baseline monitoring program that can identify and measure toxic pollutants in sediment and biota as well as in water is currently unavailable. Also lacking is a method that can optimize the design of an ambient monitoring program by providing the ideal number and placement of stations, parameter selections, and monitoring frequencies. And while existing systems may be capable of monitoring basic parameters, a practical means to assess the distribution of trace organics is needed. Also needed is a method that can evaluate the cost effectiveness of alternative monitoring network designs and optimize such networks.

Screening methods will be developed for routine use in network operations.

The actualization of these methods and programs will be pursued in a number of ways. The feasibility of a major comprehensive monitoring program will be determined. Screening methods will be developed for routine use in network operations. Monitoring network operations will be provided and network optimization techniques will be developed as ORD assists the Office of Water Planning and Standards in evaluating and improving the cost effectiveness of its nationwide monitoring network.

In the ambient water characterization effort, emphasis will be on developing biological monitoring systems as well as on refining existing monitoring techniques, such as the Coastal Environmental Assessment System and Mussel Watch, an early warning system designed to measure concentrations of certain organic chemicals and heavy metals in biota. To define ocean disposal criteria, we will evaluate the composition of benthic communities in coastal waters where wastes are discharged or dumped. Evaluation of remote sensing as a monitoring tool and as a source of land use data will also continue, and validations of the accuracy and reliability of water quality measurement and monitoring systems will be supported by the development and supply of necessary reference materials and quality control procedures. (A6)

Environmental Fate

Decisions that affect the protection of man and his environment from pollution must take into consideration the persistence, distribution, and transport of pollutants discharged into the environment—the "fate" of pollutants. We view the issue of environmental fate as the vital intermediate step that ties a pollutant's source and volume to the specific health or ecological effects it may have. Such understandings, we believe, are required for more cost-effective, well-formed management decisions on risk analysis, waste load allocations, improved management practices, and refined chemical registration and control.

By definition, the predetermination of a pollutant's fate in the environment is a predictive process, rather than an after-the-fact characterization that may be possible following an environmental mishap. Thus, environmental fate assessments must rely on experience and scientific models to represent future events. These models must be based on four basic procedures:

- formulation of the model structure or hypothesis;
- quantitative descriptions of pollutant transport, fate, and effect processes;
- characterization of the environment; and
- testing and verification of the model.

Using reliable predictive models, a pollutant's concentration and duration at various locations in the water system can be estimated. Then, best control and management strategies can be applied so that future pollution can be reduced to the degree necessary to permit desired water uses.

While a number of adequate water quality models exist today to predict common pollution parameters in streams, rivers, lakes, and estuarine environments, they are inadequate for dealing with most toxic chemicals or most pollutants common to non-point sources. Thus, future emphasis will be both on verifying existing models to eliminate deficiencies and on the development of new models to better predict the fate of pesticides, toxic chemicals, sediments, and nutrients, so that current and future environmental management needs can be met. Increased emphasis will also be given to technology transfer to state and local water managers. (B1, B2, B3, B5, B14)

Future emphasis will be both on verifying existing models to eliminate deficiencies and on the development of new models.

Building water quality and quantity forecast models requires an understanding of the behavior of the pollutant involved, i.e., the pathways and forms by which the pollutant enters the system, the various transport, transformation, and degradation processes acting on it, and the physical, chemical, and biological characteristics of the receiving waters. Accordingly, our research will include study of the environmental processes that dictate the behavior of toxic chemicals and nutrients, especially those transport processes involved when the toxics exist as particulates or are associated with particulates. (B6, B11, B12)

We have made considerable progress over the last several years describing several of the more significant fate processes affecting pollutants in solution, i.e., hydrolysis, photolysis, biodegradation, volatilization, etc. Information from such fate process descriptions and from laboratory-derived coefficients for individual chemicals serve as important inputs for meeting the second basic requirement for a reliable predictive water quality model. In the coming years, we will seek to complete this descriptive work, then gradually shift emphasis to characterizing sediment and soils sorption/desorption processes and other key processes that act on chemicals in the sorbed state. Attention will also be given to other processes found to be germane to priority list pollutants.

Also in the environmental fate area, models used primarily for making site-specific waste load allocation decisions need to be updated with recent hydrodynamic and pollutant loading estimates. Such refinements will result in models more site specific for particular environments and better equipped to evaluate impacts of certain pollutant loads on specific systems. A series of such models will be tested and evaluated. An example is our nutrient-phytoplankton models currently used in the Great Lakes to simulate load reductions. Application of these models will help reduce the time and cost of performing waste load studies at each site. We also plan to develop and evaluate several non-site-specific model assessment techniques for future screening and gross planning purposes. These include calibrating generalized models for regional or area application. At present, we are far more confident of our models that predict water quality impacts from point sources than of those that predict impacts from non-point sources. This is due in part to the fact that there is still a great deal to be learned about sediment pollution processes, and in part to the fact that the fate of non-point loads is heavily influenced by meteorologic and hydrologic variables. (B15, B16)

Research emphasis will also be on the refinement and application of exposure assessment models that have been developed for pesticides and toxic chemical evaluation and regulation. These models are particularly useful for evaluating the exposure of specific toxic chemicals in general environments, and are valuable in determining the fate of certain new chemicals. In these models, a wide variety of general environments such as ponds, rivers, or lakes in different locations are characterized, and estimates can be made of the range of concentrations for a specific chemical in the water, biota, and sediment. Validation of these existing freshwater environment models will continue over the next several years in laboratory microcosm studies as well as in the field. (B4, B7, B8, B10, B13, B17, B19, B20)

As indicated previously, a major gap in our knowledge of pollutant fate is a clear understanding of the behavior of chemicals in soils and sediments. We plan to study the processes involved in the movement of toxic and nutrient pollutants from water to sediments and vice versa. One particular concern is the adsorption and desorption that takes place during sediment resuspension, transport, and redeposition. Information generated from such sediment studies will be particularly useful in making management decisions to mitigate the impact of in-place toxic substances, such as the PCBs in the Hudson River and Bay, the kepone in the James River, and other sediment-related non-point source runoff. The information will also be useful in predicting impacts from dredge and fill operations. (B6, B9, B11)

> By linking ecosystem models to water quality models, we will be able to assess the threat posed to humans.

A final environmental fate research objective will be to enhance our capability to predict environmental effects resulting from specific short-term or long-term exposure levels. Research to obtain this objective will attempt to develop ecosystem effects models, then link them to water quality predictive models so that particular damage can be estimated (e.g., fraction of a particular fish species that could be killed) for any given set of water quality conditions. Also, by linking ecosystem models to water quality models, we will be able to assess the threat to humans from the consumption of marine food products contaminated by ocean disposal practices.

Determining Effects on Human Health and the Environment

People can be exposed to harmful substances in water by direct contact with water or by consuming contaminated freshwater and marine food products; aquatic systems themselves can be seriously impaired by pollutant-induced changes in the system. To make the rational decisions necessary to protect human health and aquatic ecosystems, we must apply our pollutant sources data to environmental fate modeling systems and then integrate that information to derive the data necessary to determine health and ecological effects.

The criteria now supporting water quality standards are limited; in addition, they only relate the concentration and length of exposure of a given material to a degree of effect in a specific organism. The criteria do not adequately address chronic effects in significant species, nor do they adequately consider the ecological significance of the bioaccumulation of a chemical in a plant or an animal. The criteria also do not consider sensitive or important parts of the ecosystem that are in special need of protection, and for which criteria should be established; nor do they discuss the impacts of non-point-related intermittent exposure to a pollutant. The criteria are further limited in that they only address the chemical quality of the body of water, not its physical features (e.g., sediment, composition, bottom configuration, depth and flow patterns), features that may be vital for the achievement of specific water uses such as maintenance of a sports fishery. In addition to the need for expanding the criteria, there is also a need for evaluating and improving the methods being used to develop the criteria. (C4, C6)

We are particularly concerned about developing an understanding of wetlands.

Our effects research program is designed to address these needs. In our research, we will improve our understanding of the structure and function of selected natural ecosystems; the information gained will provide us with a baseline against which changes can be measured and assessed and rates of recovery determined. We will also assess the importance of sediments and other non-point source pollutants and determine the physical habitat necessary for maintaining desired fish species. (C2, C9 through C13)

We are particularly concerned about developing an understanding of wetlands, such as marshes that support a variety of aquatic life and vegetation. Our projects in the area will include examinations of wetland soils and plants and the duration and frequency of their inundation. We will also address the wetlands' productivity and functions, such as nutrient transport, and their effects on water quality. Additionally, our research will attempt to produce a precise wetlands definition that can be used by the Agency, a crucial need since wetlands are currently subject to major pressures for alternative use. We will also evaluate the results of the use of wetlands for wastewater treatment. (C15)

Since the most critical of all marine ecosystem habitats are estuarine, we will continue study of the structure, function, and resiliency of typical estuarine habitats, with a focus on their importance to the whole marine system. We will examine impacts from such common activities as:

- commercial and industrial siting on the waterfront or seabed;
- land development for housing and recreational activity;
- dredging and harbor construction and related dredge spoil disposal;
- industrial effluents and sewage discharges; and
- commercial harvesting of shellfish. (C11)

Our Chesapeake Bay Program research will concentrate on three priority areas of estuarine impact:

- accumulation of toxics in the food chain;
- the overabundant growth of plants and animals; and
- the disappearance of submerged aquatic bay grasses.

Our Great Lakes program will be devoted to similar areas pertaining to large lake systems, with emphasis on problems associated with the accumulation of PCBs and other organic toxicants in the food chain.

The most critical of all marine ecosystem habitats are estuarine.

Existing or potential hazards to the environment and to man from single toxic pollutants or complex pollutant mixtures in the food chain must be evaluated. (C13) Our research to support these evaluations will include development and validation of realistic test procedures. We will continue developing whole life-cycle tests to study effects such as reproductive success and growth rates. Embryo-larval tests will be included as substitutes for full life-cycle tests. We will also examine variable/multiple environmental parameters such as salinity on bioassay responses. Short-term and chronic bioassay methods will be expanded to include additional species that are more representative of a wide range of environments.

Certain organisms (especially marine bivalves) that concentrate pollutants many times over their levels in natural waters (i.e., bioaccumulate) pose a distinct threat to man. Our research will be directed toward determining the movements involved in the bioaccumulation of single pollutants or pollutants in complex mixtures. We will examine the effects accumulated pollutants have on the fecundity and/or viability of larvae, on pollutant depuration, on pathological damage, and on the potential carcinogenic properties of the pollutants themselves.

The information gained from these studies will validate biological monitoring programs and will help fill the gaps in existing criteria. It will also provide the basis for the development of those aquatic ecosystem effects models that will be linked to water quality models, for the estimation of specific damage to a species in a given set of water conditions.

Information to Manage a System Cost-Effectively

Adequate information on pollution control technologies and a good sense of the cost-effectiveness they offer are both necessary for formulating realistic water quality management options. Our control technology development and evaluation plans for point sources may be found in chapter 6, "Wastewater and Spills," but in general we will continue to improve our capability to define and quantify water quality benefits and pollution abatement costs, specifically construction, operation, and energy costs. (D2, D4, D9, D13, D17)

Non-point source pollution can be controlled by a variety of best management practices.

Non-point source pollution can be controlled by a variety of best management practices including structural techniques such as terraces, grassed waterways, and runoff storage facilities, and non-structural techniques such as street sweeping, real-time fertilizer and pesticide management, minimum tillage programs and zoning restrictions. Similar watershed management approaches are applicable to the restoration and maintenance of water quality in lakes.

Our research, carried out jointly with USDA and others, will develop and provide limited evaluation of methodologies for selecting and assembling best management practices suitable for use under varying climatic, physiographic, and other environmental conditions, practices that will achieve optimum receiving water quality benefits. Initially, we will evaluate the effectiveness of existing conservation practices as potential BMPs with emphasis on selection for specific locations. Finally, we will develop techniques to evaluate the cost effectiveness of using combinations of BMPs. In this effort, our emphasis will be on using field evaluation data to test and demonstrate BMP capabilities and to evaluate the ability of specific practices to achieve water quality goals. Similar efforts will be carried out to identify the most effective techniques both for restoring and for maintaining our water quality. (D1 through D4, D6 through D8, D10 through D12, D14 through D16, C8)

Working with USDA and others, we will also evaluate new or improved BMPs to identify the advantages and limitations that such strategies as incentives and regulations will have on the implementation of NPS control programs on public and private lands. When recommending management alternatives, we will take into full consideration potential social acceptability, energy requirements, and cost-effectiveness relationships. In addition, where best management practices may not be the most efficient means for alleviating non-point source impacts to offset pollutant harm, we will examine comprehensive approaches, such as total watershed management, in which control of pollutant sources is combined with the design of in-stream systems to protect associated wetlands and downstream water quality.

WATER QUALITY RESEARCH PLAN

PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
Sources and Ambient Pollutant Identification and Measurement.	Develop first generation methods for genera pollutants. **A-1**		Continuing Activities		
	Selected priority toxic pollutants (w/emphasis on water and wastewater.) **A-2**	Additional priority toxic pollutants (w/emphasis on water and wastewater). **A-7**	Reference measurement methods for remainder of priority toxic pollutants. **A-9**	Correct deficiencies in selected reference measurement methods for priority pollutants in sludge, biota, sediment, soil, leachate, wastewater. **A-14**	Correct deficiencies in selected reference measurement methods for priority pollutants in aqueous and related materials. **A-19**
	Develop broad spectrum measurement techniques. **A-3**		Continuing Activities →		
	Broad spectrum measurement technique for volatile organics in water and wastewater. **A-4**		First generation broad spectrum measurement technique for non-volatile organics in water and wastewater. **A-10**		Expand broad spectrum organics measurement methods for application, to sediment, soil, sludge, and leachate. **A-20**
			Develop rapid screening biochemical/biological methods for toxicants in water. **A-11**	Continuing Activities →	
				First generation bioassay methods for rapid screening of toxicants in complex effluents. **A-15**	Improve and expand biological/biochemical rapid screening methods for toxicants. **A-21**

PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
	Characterize typical contribution of pollutants from selected point and non-point sources, including atmospheric contributions. **A-5**		Continuing Activity		→
				Characterize atmospheric contributions to water pollution. **A-16**	
	Analytical method development. **A-6**		Continuing Activity		→
		Treated reference method for asbestos in water and wastewater. **A-8**	Multielement measurement technique for sediment soil, and suspended particulates. **A-12** First generation biological/biochemical rapid screening methods for toxicants in water. **A-13**	Identify frequently occurring toxic organics in industrial effluents. **A-17** Measurement technique for speciation of toxic metals. **A-18**	Reference methods for toxic chemicals added to EPA priority pollutants. **A-22**

WATER QUALITY RESEARCH PLAN

PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
Environmental Fate	Workshops on uses of existing predictive models for assessing nonpoint and point source impacts on receiving water quality. **B-1**	→	Continuing Activity →	→	→
	Water quality modeling center for model dissemination and limited technical assistance. **B-2**	→	Continuing Activity →	→ Joint center (w/operating programs) for routine production of transport and fate processes data. **B-14**	→
	Water quality predictive model. B-3	Evaluate selected water quality predictive models for use in assessing NPS pollution and control measures in Chesapeake Bay area. **B-5**	Expand water quality predictive models to address sediments in streams. **B-9**	Improved nutrient cause and effect models for AWT facility and NPS control planning and tradeoff analysis. **B-15**	Field validation of detailed irrigation-return flow model for predicting water quality changes resulting from NPS implementation. **B-18**
			Expand predictive models to address selected priority toxic pollutants in streams and impoundments. **B-10**	Field validation of selected water quality models that address common pollutants and associated NPS loadings. **B-16**	Expand water quality predictive models to address additional priority toxic chemicals. **B-19**

WATER QUALITY RESEARCH PLAN

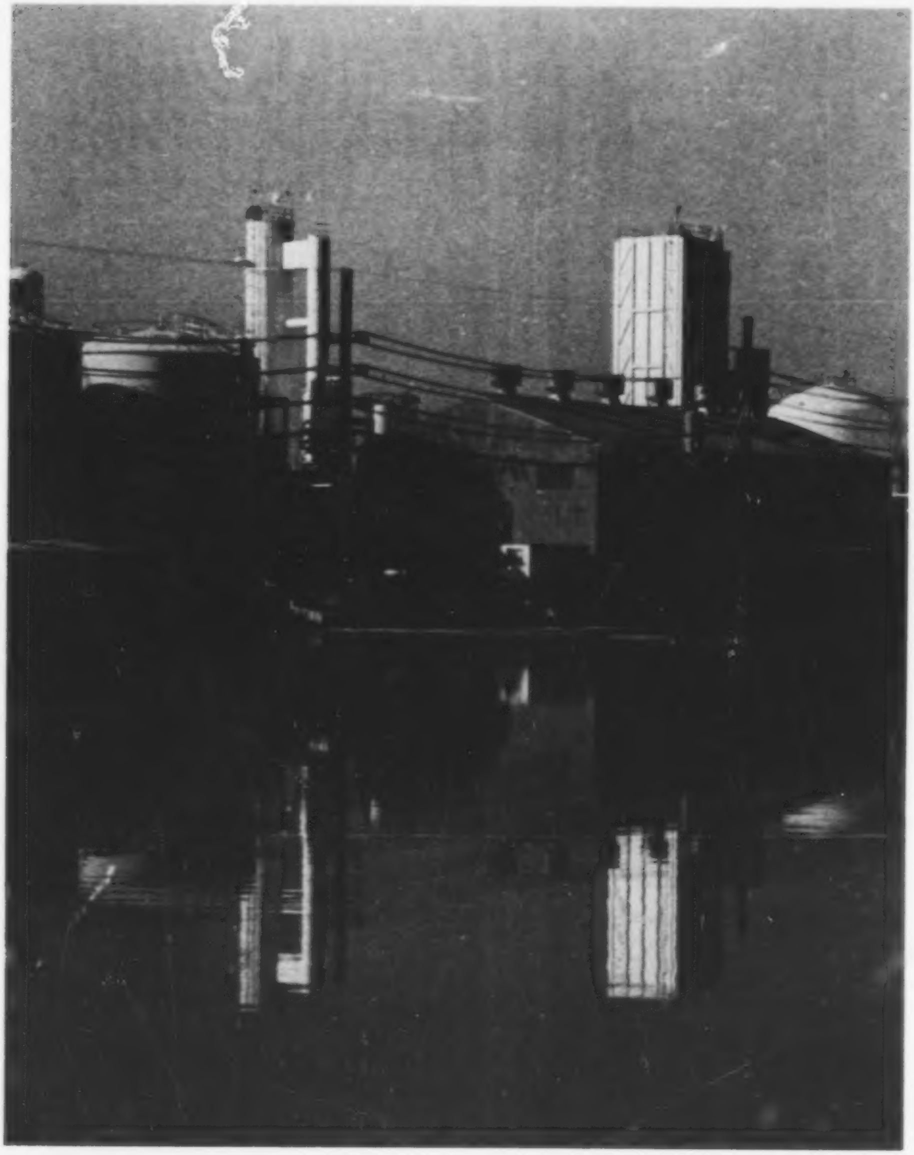
PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
			First generation capability to predict sorption and desorption of pollutants to and from sediments. **B-11**		
		Identify role of sediments as a source and sink of toxicants in Great Lakes. **B-6**	Characterize transport and fate of PCBs in Great Lakes. **B-12**	Model set for assessing selected toxic chemicals in Great Lakes. **B-17**	
	Exposure assessment predictive model. **B-4**	Refine and validate Exposure assessment model for predicting toxic organic chemical persistence and fate. **B-7**	→	→	Exposure assessment model for predicting movement, cycling, fate, and speciation of toxic metals in aquatic systems. **B-20**
		Characterize transport and fate of selected pollutants in subsurface environment. **B-8**	Characterize subsurface environment as it influences pollutant transport and fate. **B-13**		

WATER QUALITY RESEARCH PLAN

PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
Environmental Effects	Criteria for marine recreational waters. **C-1**	Criteria for fresh recreational waters. **C-3**	→	→	→
	Interim criteria protective of aquatic life for current priority toxic pollutants **C-2**	Appraise applicability of bioassays using short-lived species to predict human health effects. **C-4**			
		Appraise health effects posed by selected priority toxic pollutants. **C-5**	→	Characterize bioaccumulation properties of priority pollutants through fresh and marine food chain and impact on humans. **C-12**	→
		New test procedures for characterizing chronic effects of toxicants on marine aquatic life. **C-6**	Characterize ecosystems effects from intermittent exposures to selected NPS pollutants. **C-9**	→	Ecosystem models for transmitting intermittent water quality levels into ecosystem effects. **C-14**
			Criteria protective of acute and chronic effects on aquatic life for selected priority pollutants. **C-10**	Continuing Activities →	→ Characterize the functions and productivity of wetlands. **C-15**
			Characterize fate and effects of ocean disposed water (support 301(h) permit activities). **C-11**	→	→
		Assess impacts of sediments on aquatic biota and define aquatic habitat criteria for streams in areas polluted by non-point sources. **C-7**		Assess human exposure and risk from marine food products contaminated by ocean disposal practices including dredge spoil. **C-13**	

PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
		Complete evaluation of first generation clean lakes projects and publish lake restoration guidance manual. **C-8**			
Water Quality Management	Procedure for evaluating and ranking alternative agricultural best management practices (BMPs). **D-1**	Interim protocols for selecting site specific agricultural BMPs **D-3**	Evaluate biological improvements in receiving waters resulting from implementation of BMPs in selected rural areas. **D-6**	Improve characterization of soil processes for model refinement and BMP selection. **D-10**	Coordinate with USDA to document effectiveness of BMPs for irrigated agriculture and nonirrigated agriculture. **D-14**
	Document effectiveness of in-place management practices for controlling pollution from urban runoff. **D-2**	Interim methodology for evaluating urban stormwater quality management alternatives. **D-4**	Evaluate selected urban runoff pollution management practices. **D-7**	Evaluate biological improvements in receiving waters resulting from implementation of BMPs in selected urban areas. **D-11**	Technique for assessing irrigation return flow, pollutant sources and BMP effectiveness. **D-15**
			Interim summary of influences of land use solids disposal practices, and pollution on urban runoff pollution management strategies. **D-8**	Update evaluation of effectiveness of implemented urban runoff management practices. **D-12**	Evaluate additional urban runoff pollution management practices (sewer flushing & various in-line control systems.) **D-16**
		First generation methods for assessing water pollution control impacts. **D-5**	Framework of systematic procedures for calculating water quality improvements from proposed alternative point and non-point source control strategies. **D-9**	Compile dollar values to be assigned to various water quality improvements, for use with procedures for calculating net and value of site specific water quality benefits. **D-13**	Systematic procedures for calculating and comparing costs and benefits of proposed point and non-point source control strategies. **D-17**

WASTEWATERS AND SPILLS



Wastewaters may introduce toxicants into the environment. EPA is developing methods to better treat and recycle wastewaters.

The daily discharge of industrial and municipal wastewaters in the United States is estimated to be 100 billion gallons, a total equivalent to the average flow of the Mississippi River at St. Louis. These wastewaters contain chemicals, suspended solids, bacteria, and viruses—many dangerous to the environment and to public health. Depending on their concentrations, the toxic chemicals in wastewater can cause cancer, mutations, birth defects and a variety of other human health effects. In our streams and lakes, wastewater pollutants can deplete the dissolved oxygen levels required for support of aquatic life, make the water cloudy or colored, or lead to otherwise unsightly effects. Wastewaters finding their way below the earth's surface can also seriously affect the quality of our groundwater supplies.

The Problem—Industrial Wastewater

About two-thirds of the nation's point-source wastewaters are "industrial." The character of industrial wastewater varies, however, from fairly innocuous cooling waters to the highly toxic wastewaters from such industries as solvent and dye manufacturing, electroplating, and pesticides production. Wastewaters generated by industry can contain enormous quantities of BOD, COD, suspended solids and nutrients, and a wide variety of acids, alkalies, salts, heavy metals, synthetic organic chemicals, inorganic solids, oil, and grease.

According to Department of Commerce projections, United States manufacturing industries will more than triple their present production output by the year 2000. Projections also point, however, to an important trend toward higher industry water recycling and reuse. Thus, while gross manufacturing use of water is projected to increase from 153 billion gal/day in 1975 to 371 billion gal/day in 2000, total discharges are projected to decrease from 60 billion gal/day to 6 billion gal/day over the same period. These projections assume that major water users, including the emerging synfuels industry, will adopt water recycle/reuse technology. Much of that technology, however, is still to be developed and demonstrated. And while water recycle/reuse will decrease wastewater discharges, the remaining concentrated residues will still have to be safely disposed of—by destruction, conversion to a harmless form, release to the air, water or land, or by incorporation into some useable product.

The Problem—Municipal Wastewater

Over 22,700 municipal wastewater treatment plants currently exist in the United States. These plants treat the domestic wastes of over 164,000,000 people, as well as a significant amount of industrial discharge. The plants discharge 26 billion gallons of wastewater daily into our nation's waterways, lakes, oceans, and land surfaces; in addition, our waters are subjected to another 16 billion gallons of wastewater per day from urban runoff. If all of our municipal wastes are not correctly treated and managed, they might become agents of diseases such as cholera, typhoid fever, and other enteric infections; improper treatment can also contribute to the deterioration of our water resources.

By the year 2000, treated municipal point-source discharges will amount to between 72 percent and 88 percent of the total point-source discharges of biochemical oxygen demand, suspended solids, nitrogen, and phosphorus. The nature of these municipal discharges will, therefore, play an important role in determining the nation's overall water quality. Currently, there is not adequate information to define the present contribution or project the future contribution of priority pollutants in municipal point-source discharges.

Controlling Industrial and Municipal Wastewater

The legislative basis—industrial wastewater. The discharge permit, issued by state regulatory agencies or EPA, is the legal mechanism used to control industrial wastewater effluents. This permit is generally based on industry-wide effluent guidelines published by EPA. Current guidelines are "technology based"; that is, they are based on the level of pollution control for an industrial discharge that can be achieved by available and proven control technology. Originally, guidelines focused primarily on gross pollution parameters (e.g., BOD, COD, and suspended solids) and on a few selected pollutants or pollutant classes of known concern (e.g., mercury, cadmium, PCBs, chlorinated hydrocarbons, etc.). Recently, however, impelled by a 1976 Consent Decree settlement with the Natural Resources Defense Council and by 1977 amendments to the Clean Water Act, EPA has been reviewing and revising these technology-based guidelines, giving special attention to the 21 industries and 129 priority pollutants identified in the Consent Decree.

Provisions of the Clean Water Act also call for discharge limits.

Provisions of the Clean Water Act also call for discharge limits which, when required, can be substantially stricter than technology-based limits. They allow for the setting of discharge limits aimed at maintaining a specified quality in the receiving waters themselves, not just in wastewater effluents. These "water quality-based" standards can be applied when the level of control possible through a technology-based standard will not achieve receiving water quality suitable for desired water uses.

Over the next few years, technology-based guidelines will be employed for Best Conventional Technology (BCT), Best Available Technology Economically Achievable (BATEA), and Best Management Practices (BMPs). This effort will result in the best possible near-term control of industrial pollutants; it is calculated to alleviate the most serious point-source pollution problems and encourages the application of already existing pollution control technologies and methods. The approach aims to minimize the discharge of conventional and the specified 129 priority pollutants to the greatest degree economically and technically feasible.

The Clean Water Act establishes a national goal of "no discharge" of pollutants to United States navigable waters by 1985. One way to achieve this goal, even in the face of constant proliferation of new chemicals and increased manufacturing, is to recycle and reuse wastewaters. This method can aid in the control of water pollution as well as effectively increase our nation's water supply, a particular benefit to areas of the country subject to periodic and increasingly frequent water shortages.

The Clean Water Act also provides for local control over industries that discharge their wastes into municipal sewage collection systems. When wastes are discharged in this way, a municipality can require an industrial discharger to apply on-site pre-treatment or otherwise restrict the release of certain waste constituents that are either not effectively handled by the treatment plant or which adversely affect its operation.

The legislative basis—municipal wastewater. The discharge permit, issued by state regulatory agencies or EPA, is the legislative mechanism for controlling municipal wastewater effluents. This permit is based on either (1) a minimum national secondary treatment standard of 30 mg/1 suspended solids (SS) and 30 mg/1 biochemical oxygen demand (BOD), or (2) a water quality-based standard. Approximately 7,600 municipal treatment plants are bound to water quality-based standards for nontoxic pollutants and require either higher levels of SS and BOD removal or removal of additional contaminants such as coliforms, ammonia, nitrogen, or phosphorus. For those facilities bound to secondary treatment standards, the Federal Water Pollution Control Act Amendments of 1972 additionally stress the need for wastewater recycling and reuse, especially land treatment, toxics control, and improved pollution control in rural areas where conventional sewage collection or septic tank treatment is impractical. Toxic control will emphasize the 129 Consent Decree Pollutants.

The Clean Water Act of 1977 provides funds for the construction of municipal wastewater treatment facilities; specific set-asides for individual home waste treatment facilities and innovative and alternative technologies that emphasize cost reduction, energy conservation, toxics control, improved reliability and the recycling/reuse of water, nutrients, and sludges are also provided for. The Act requires the promulgation of guidelines for sludge disposal and use on the land, encourages aquaculture (the take-up and use of wastewater by waterborne plants and other organisms) and wastewater land treatment, and allows for the waiving of secondary treatment requirements for marine discharges providing certain criteria are met. Publicly owned treatment works (POTW) toxics control for substances primarily of industrial origin will be achieved mainly through pretreatment regulations for industries whose wastes feed into POTW facilities.

The Research Plan—Industrial Wastewater

EPA's industrial wastewater research plan is designed to provide information on the cost-effective control of industrial pollutant discharges. To accomplish this task, we must:

- detect and identify pollutants;
- determine their source and the form and concentrations in which they are discharged;
- establish their susceptibility to known methods of treatment and control;
- develop and demonstrate treatment methods or non-treatment alternatives including techniques for recycle/reuse for those pollutants not susceptible to known control methods; and
- develop monitoring methods to assure that waste discharges do not violate quality guidelines.

This chapter will emphasize the engineering and technological aspects of the plan. For projected research on analytical and monitoring methods, and on fate and transport of water pollutants, see chapter 5, "Water Quality."

The four basic research objectives of the wastewater treatment and control program are the following:

1. To increase the efficiency of pollutant removal beyond present limits;
2. To increase the performance reliability of available control methods;
3. To reduce the costs and energy requirements necessary to construct and operate treatment and control facilities;
4. To emphasize the beneficial use of nutrient materials, properly treated sludges and renovated wastewaters and to optimize the use and production of energy in POTWs.

Our research to support technology-based standards focuses on the assessment of available technology and on bringing newly-developed control methods into practical use. Our research to support water quality-based standards explores and develops new techniques and adapts and extends existing ones to achieve ever-higher control levels for selected pollutants.

Previous emphasis in dealing with industrial water pollution problems involved control at the point of discharge. Such improved end-of-pipe technology development is still a necessity, but in the near future, non-treatment techniques that reduce toxic and conventional pollution problems while conserving water, energy, and other resources will have a major program emphasis as well, particularly for new pollution sources.

Improved end-of-pipe technology development is still a necessity.

In addition to our interactions within EPA and with other federal agencies, we will continue to meet with industry and university experts to avail ourselves of their particular insights and expertise. Over the next five years, industrial wastewater research and development may be categorized into one of three areas:

1. Industrial source characterization and assessment;
2. Control methods evaluation, research, development, and demonstration;
3. Recycle/reuse research, development, and demonstration.

Industrial Source Characterization and Assessment

Our approach in this area involves desk-top analyses of the manufacturing processes and unit operations of concern. The analyses to be performed by expert chemists and engineers will be to provide insight into which waste products will most likely be generated and emitted to the environment. These analyses will be designed to predict pollutant impacts on air and land, as well as on water, so that important cross-media implications of industrial water pollution control will not be overlooked. Following the desk-top effort, field sampling and analysis at industrial plant sites will be conducted. Both conventional pollutants and specific chemical compounds will be measured. Where possible, these characterization and assessment studies of specific industries will be generalized to industries with similar discharges.

The most crucial prerequisite for a characterization and assessment program is dependable analytical methods. (Gaps in existing measuring technology and an outline of our program to fill them are discussed in chapter 5, "Water Quality.") For the efficient study of industrial wastewater, we are particularly in need of developing indicators that signal the presence of both individual and groups of toxic components, and surrogate parameters that indicate their quantity. The use of such indicator/surrogate analysis methods will reduce the number of parameters necessary to characterize the pollution and toxic potentials of industrial waste streams. Parameters to be considered will include measurements of chemical compounds or classes of compounds and bioassy-type measurements where a property of a waste stream such as its "toxicity" will be evaluated. (IA20)

Conventional pollutants and specific chemical compounds will be measured.

A continuing source assessment effort is contemplated. Sites will be selected based on the technical information required, but selection will also reflect specific Agency policy and regulatory needs and concerns. In addition, the program will evaluate energy-conserving process changes to determine their environmental implications. (IA18)

Control Methods Evaluation, Research, Development, and Demonstration

Treatability—Information that defines the degree to which various pollutants can be removed or "treated" by candidate technologies is imperative for guidelines development and the issuance of discharge permits. We will, therefore, conduct research to determine and/or predict the "treatability" of specific toxic pollutants and/or classes of pollutants by a wide range of physical, chemical, and biological waste treatment processes. (IB1, IB2, IB3, IB6, IB10, IB18, IB21) Basic treatability data applicable to both industrial and municipal waste treatment are currently being collected, and a Treatability Manual is being prepared as a reference for effluent guideline developers, permit writers, and design engineers. (IB4) The manual will include data on a wide range of compounds, operational data for the control facilities employed, and design criteria for various technologies, and will be updated and reissued periodically. (IB12, IB16, IB19, IB20) Pollution control guidance documents covering treatability and other environmental issues will also be prepared for emerging industries. One such document on geothermal energy has already been completed while others on oil shale, coal conversion, and gasohol production are planned. (IB5, IB7, IB8) Others will be prepared as appropriate. (IB14, IB15)

A Treatability Manual is being prepared.

A compound's treatability depends on the various chemical interactions that take place within complex effluents. A full understanding of all the mechanisms and interactions involved presents a significant research challenge (IB17), and it is doubtful that a complete theoretical understanding will ever be reached. However, empirical data will be developed that will provide a basis for estimating the ability of various treatment processes to remove both conventional and priority pollutants. (IB13, IB23)

We will also work at identifying treatability surrogates—chemical compounds or other measurable parameters that will respond to treatment in the same manner as those compounds or as whole classes of materials of concern. (IB11) Once such a surrogate is identified for a given type of treatment such as biodegradation or adsorption, it could be utilized in place of measuring a number of actual compounds, reducing the complexity and cost of evaluating treatment alternatives and of monitoring and controlling treatment processes and treatment trains.

We will also often be interested in determining the ability of a control method to reduce the "toxicity" of a waste, perhaps without even knowing or understanding at the time what chemical entities are being removed. Thus, development of biomonitoring methods that indicate toxicity will aid in determining how effectively a given control method treats toxics.

Treatment technology and non-treatment alternatives — Defining the efficiency of treatment processes for individual toxic pollutants is but a small part of the total industrial pollution control picture. We must also optimize and improve currently available treatment methods, and develop innovative technologies or non-treatment alternatives to meet new pollution control challenges.

Conventional as well as new technology will be evaluated.

We are currently developing tools to perform pilot-scale experiments with a variety of treament process modules, either singly or in combination. There will be both fixed facilities and mobile units that can be taken to industrial plant sites. These facilities will be useful in the development and testing of industrial direct discharge and pretreatment control technologies, and will allow EPA to react quickly to new problems by providing the technological information and recommendations necessary for their control.

Conventional as well as new technology will be evaluated through analysis of available data, from bench-scale and pilot-scale experiments, and from prototype full-scale installations. New and modified biological and physical/chemical treatment processes will be examined to determine their relative cost/performance effectiveness. (IC11) Cross-media impacts will be identified and evaluated; for example, the amounts of volatile organic compounds stripped to the air during aeration of wastewater treatment will be measured. Using such data, decisions can be made to determine where such pollution releases to the atmosphere may themselves need to be controlled to prevent air quality degradation. As new control technology is developed and introduced into practice, it will be necessary for us to take those analytical methods devised for pollution detection and measurement and adapt them for compliance monitoring and on-line control of treatment processes.

Cross-media impacts will be identified and evaluated.

Throughout our wastewater control technology development program, close attention will be paid to ways to reduce cost and energy consumption. (IC5) Once installed, treatment technology will be monitored to determine real world performance and to provide feedback to the research program.

There are a variety of alternatives to end-of-pipe treatment that are either existing or under consideration. Any of these could be used alone or in combination with treatment for pollution control. In some instances different raw materials could be used or new manufacturing techniques employed. Improved housekeeping through application of Best Management Practices may also prove effective. (IC9, IC20)

We will evaluate and model selected chemical reactions used broadly in the chemical industry. This effort will help us to predict the occurrence of toxic constituents in the wastewaters produced and to identify possible process changes, raw material substitutions, or other techniques that could eliminate or minimize the generation of the toxic wastes. One possible approach, for example, is to "re-design" chemical products to make them less polluting, more treatable, or non-persistent in the water environment. (IC24)

We will evaluate and model select chemical reactions.

The conversion of "hard detergents" to "soft detergents" some dozen years ago is an example of this approach. As viable non-treatment alternatives are identified (IC17, IC25), the program will also define the optimum balance of treatment and non-treatment alternatives in combination. (IC22)

We will encourage industry and assist where funding permits in developing and demonstrating less polluting manufacturing concepts (IC23), ranging from innovative process modifications to entirely new manufacturing techniques. These concepts may be an outgrowth of fundamental research, or may, by contrast, be concepts in full-scale practice in other industries or in a foreign country. Here, the need may be to adapt and demonstrate the technology for American industrial practice to assure its technical and economic soundness. The metals industry, for example, might benefit from exposure to the innovative technology found in European and Japanese installations rebuilt following World War II. Much of foreign technology is designed with energy conservation as a high priority, since most foreign countries face generally higher fuel costs. (IC2)

Recycle/Reuse Research, Development, and Demonstration

While we agree with the Department of Commerce that a major shift by industries to recycle/reuse water systems lies ahead, we feel that much remains to be accomplished regarding these systems before their wide-scale adoption can be expected. Many of these advances must and will be made by the industries themselves as new sources or reliable water supplies dwindle and as effluent limitations become more stringent. Thus, to some extent the move to water recycle/reuse is a natural, almost inevitable, circumstance. We will attempt to accelerate that move by concentrating our efforts on those situations where:

- highly toxic chemicals are involved and their release into the environment must be reduced to the absolute minimum level; and
- alternative solutions to pollution control problems are not being brought rapidly into full-scale practice.

For several years we have been studying operational recycle/reuse systems to facilitate the development of effluent guidelines. Sometimes, however, the data are not sufficient for drawing conclusions on the transferability of a given system to industrial plants of various sizes and types. In the future, we will use an approach that will enhance consistent evaluations of existing systems and will facilitate applicability in a variety of installations. (ID4) We will also plan to amplify our efforts on those industrial pollution problems where water recycle/reuse can result in more cost-effective pollution control.

The factors that influence strong interest in recycle/reuse are several:

- the severity of the existing water pollution control problem;
- the amenability of the problem to conventional control;

- the extent of the water demand;
- the relative cost of alternative control methods; and
- the extent to which recycle/reuse can directly satisfy EPA regulatory program objectives.

Based on these factors, example industries likely to require recycle/reuse technology are organic chemicals manufacture (including pesticides, dyes, plastics, etc.), iron and steel, and textiles. (ID1, ID5, ID6)

In the near term, the greatest potential for success in stimulating acceptance of recycle/reuse systems may lie in those applications and with those pollutants for which we have the most existing data. For this reason, we will include demonstrations of recycle/reuse where conventional pollutants and high water use are at issue. Over the longer term, however, it is our objective to place prime focus on recycle/reuse as a tool for resolving otherwise intractable or particularly costly pollution control problems involving toxics-containing effluents.

Why a Fundamental Research Component Is Needed

An "outlook" for future research would not be complete without mention of longer-term fundamental research needs and goals. Such work is necessary to develop a data base for solving the "next generation" of industrial waste pollution problems, to allow intelligent extrapolation of current knowledge to new applications, to enhance our ability to react to unexpected events, and to aid in the training of experts upon whom EPA and others can depend. Specifically, our researchers will need to know more about the mechanisms and kinetics involved in the generation and destruction/detoxification of industrial pollutants and about the mechanisms that separate such pollutants from water. Our goal should be to achieve a basic understanding of industrial pollution problems and the various methods for their control, ensuring that informed decisions can be made for the optimum, most cost-effective solution for each.

The Research Plan— Municipal Wastewater

The municipal wastewater research plan is designed to provide technical information on the design, operation, cost, and performance relationships of municipal pollution control technology alternatives. Our goal is to optimize the environmental efficiency of municipal wastewater treatment facilities, to beneficially utilize nutrients in wastewaters and sludges and to optimize the energy aspects of municipal wastewater management. Specific objectives of our research program are to provide wastewater treatment and associated sludge disposal technologies that:

- reduce capital and operating expenditures;
- consume less energy and resources or actually produce useful energy or other valuable by-products;
- are environmentally safe with regard to water quality, air quality, and land utilization criteria for all intended uses;
- operate reliably and provide a high level and/or a comprehensive pollutant removal capability;
- provide sanitary waste disposal alternatives regardless of location or site-specific constraints; and
- are compatible with or adaptable to existing facilities, technologies, and other regulatory programs.

To meet these objectives, research will be carried out in the following areas:

- developing and evaluating municipal wastewater treatment processes;
- land treatment and aquaculture;
- sludge processing, use, and disposal
- toxics control;
- improving the operation and reliability of POTWs;
- helping small communities choose treatment and disposal alternatives;
- controlling pollution from urban runoff;
- using water that has been treated;
- innovative and alternative technology.

Where appropriate, research efforts will be coordinated with EPA regional offices, regulatory and enforcement agencies, and interested industrial and municipal parties.

Research Program Areas

Developing and Evaluating Municipal Wastewater Treatment Processes. The predominant BOD and suspended solids removal methods employed in the United States are activated sludge, trickling filters, and stabilization lagoons. Because of the extensive use of such biological processes in municipal wastewater treatment facilities, our program will give high priority to bringing costs down and developing more energy-efficient biological systems capable of the traditional functions of organic carbon and suspended solids removal as well as phosphorus and nitrogen control. (MA2, MA7)

We will pursue the development of higher rate and less land-intensive processes for future treatment plants. Vertical systems such as deep shaft aeration systems (MA6) combining attached and suspended growth reactors (MA5) will be evaluated, as will fluidized bed reactors (MA9) and multipurpose reactor/clarifiers. We will also evaluate such new concepts as batch processing in place of continuous flow systems, and develop improved methods for the control of toxics.

The majority of municipal secondary treatment facilities depend on the transfer of oxygen for efficient operation. Since oxygen transfer is a significant cost- and energy-intensive process, we will direct efforts to increase the efficiency of this operation. The application of aeration technology to the process, for example, would increase transfer efficiency from the current 5 percent to a more acceptable 15 percent and could, on a national basis, result in an annual operating cost saving of $60,000,000. (MA8)

Ultraviolet light and ozone are the prime candidates for replacing chlorination.

Since hazardous chlorinated organics can be formed when chlorine is used for disinfection, we must provide municipalities with other more environmentally acceptable choices. Currently, ultraviolet light and ozone are the prime candidates for replacing chlorination and both are about to enter full-scale second-generation application. (MA1, MA4) Initial test results and field evaluations showed these alternatives to be practical, efficient, and not cost prohibitive.

Land Treatment and Aquaculture. We are presently studying three major types of land treatment systems. (MB1) *Slow rate systems* are the most commonly used, and, in most cases, we have reliable criteria available for their design and operation. *Overland flow systems* are the least used, owing primarily to the paucity of design data and lack of operating experience. (MB3) *Rapid infiltration systems* are fairly widespread, but several questions regarding their design and operation have restricted their use. (MB5)

The thrust of our research in this program area is to develop reliable design and operating criteria for all three types of systems enabling us to utilize them to their fullest extent and under all possible operating conditions. Research will focus on:

- the design and proper operation and maintenance of rapid infiltration and overland flow systems;
- optimizing the treatment capability of all land treatment systems;
- assuring maximum protection for the groundwater; and
- minimizing potential problems related to disease transmission, heavy metals, and toxic organics.

Major concerns posed by the implementation of land treatment involve disease transmission (MB7), particularly by viruses; the fate of heavy metals in the soil (MB8), their uptake by crops, and migration to groundwater; and the fate and transformation of toxic organics. Research aimed at examining these concerns will be ongoing over the next five years.

The use of wastewater for aquaculture is a wastewater treatment thought to have great potential. Aquaculture, as defined by our program, is the use of water plants, particularly the water hyacinth, and other aquatic organisms to take up, use and therefore biologically modify the wastes in wastewater. Our program does not include the use of potential food sources for treatment. Research into various aquaculture processes is currently being conducted by several organizations and agencies, including EPA.

The EPA aquaculture research program, though not a major one, has nevertheless availed itself of experts in the field to set research priorities and establish a five-year wastewater aquaculture research plan. Emphasis is being given to the development of systems utilizing aquatic macrophytes, particularly water hyacinth. (MB4, MB6) Care is being taken in the design and location of these systems to prevent the creation of nuisance infestations in surrounding areas. A few systems have been built and are operating, and additional pilot-scale and developmental systems are being planned. Additionally, EPA is conducting research into the use of natural and artificial wetlands for wastewater treatment and management (MB9), and the use of finfish systems for advanced treatment, particularly nutrient removal. (MB2)

> POTW sludge processing and disposal can account for as much as 50 percent of total wastewater treatment cost.

These systems have potential as effective wastewater and wastewater nutrient recycle/reuse processes. Certain systems may also be used to produce energy, converting the harvested biomass into gas. Our research program is committed to developing effective and economical aquaculture processes as wastewater treatment alternatives.

Sludge Processing, Use, and Disposal. POTW sludge processing and disposal can account for as much as 50 percent of total wastewater treatment cost. Recently it has been found, however, that in some cases sludge can be converted into resources, and can even return some treatment costs. There have also been recent improvements in sludge treatment, disposal, and utilization technologies, particularly in the long-neglected area of sludge disinfection. One outstanding development has been sludge composting, a process that essentially pasteurizes sludge, at a low capital cost and with minimal odor problems. (MC3, MC9) New methods for thermal conversion of sludge, such as low-air combustion, co-incineration with refuse, and the burning of dewatered sludge with no other auxiliary fuel for conventional incineration, have also been developed and demonstrated.

We will continue our search for improved cost- and energy-effective processing routes and methods for sludge land treatment and disposal. Emphasis will be placed on developing improved stabilization methods for the destruction of pathogens. Where land treatment and disposal are not feasible, we will work to improve environmentally sound and energy-wise methods of thermal sludge processing. (MC4, MC5, MC6, MC10, MC11)

Currently, one of the most cost-effective uses of sludge is as a soil amendment or fertilizer in agriculture and for land reclamation. (MC6) While such use is common in the United States, it has been generally thought applicable only to small rural communities. Working with the USDA and the City of Chicago, we are demonstrating the potential of this particular use for larger cities.

While researching the land treatment of sludge, we realize that such treatment poses some threat to the environment. We know that despite processing, some pathogenic organisms are apt to persist; heavy metals and toxic chemicals will also be present in trace amounts. We are thus concerned that effects such as plant uptake may occur. We are also still uncertain about disinfection requirements and acceptable cadmium loading rates, and are yet unsure of what constitutes a "stabilized" sludge. Nutrient content, pH management, and the effect of certain agents in the sludge on the mobility of heavy metals are also of concern. We must, therefore, examine these parameters and potential effects, and develop measures to minimize them to assure cost effective wide-scale application of sludge on agricultural lands.

In the past, we have worked closely with the USDA Beltsville Research Center to identify long-term environmental effects of sludge utilization. We have also worked with the Food and Drug Administration to examine transfer of toxics to the human food chain. We are currently working with these agencies and the academic community to determine the nature of crop uptake of potentially toxic metals, including cadium.

Our future efforts will be directed toward indentifying methods to reduce levels of toxic metals and organics in sludge to make it more amenable for land use. We will examine the long-term impacts of sludge-spreading on a variety of soils and crops, and will also attempt to determine the fate of the organics when the sludge/organics mixture is applied to the land. (MC12) In the event that the uncertainties associated with sludge application to food crops are not resolved, the program will evaluate non-food crop land application alternatives as well as "sludge to useful products" conversion technologies. (MC2, MC7, MC8, MC13)

The immediate objective of the toxics control program is to clearly define the municipal wastewater problem.

Toxics Control. All municipal wastewaters, whether derived from purely domestic sources or from mixed industrial/domestic sources, contain many toxic metals and organics on the priority pollutant list. In a two-city survey, 29 of the 129 pollutants were detected in domestic wastewater and 49 in industrial/domestic wastewater.

The immediate objective of the toxics control program is to clearly define the municipal wastewater problem. The objective will be accomplished by acquiring data bases on the occurrence of priority pollutants in municipal wastewater influents, effluents, and sludges. To this end, surveys of some 65 cities are currently being conducted by the Office of Research and Development (MD2) and by the Office of Water Planning and Standards. As a corollary, a second, short-term objective has been the development or modification of analytical procedures to allow the data base collection to proceed.

A principal near-term objective of the municipal program, in conjunction with the industrial wastewater research program, is the assessment of the treatability/removability of priority pollutants by a variety of treatment processes including biodegradation, carbon adsorption, and air stripping. (MD1, MD3) With the enormous number of compounds to be tested as part of this assessment effort, we are working on methods of accurately forecasting the behavior of a compound in a given treatment process without actually having to test that particular compound. This can be accomplished by relating the fundamental characteristics of a compound, such as the parachor number, partition coefficient, and molecular weight, to known treatability/removability parameters.

For the short term, we will conduct tests to determine how organic compounds concentrations change from influent to effluent during sludge treatment. This change or removablility is influenced in a complex process such as activated sludge by several processes, mechanisms operating concurrently and interdependently, including stripping, biodegradation, adsorption, precipitation, hydrolysis, etc. A clearer understanding of removability can provide a deeper insight into the general effectiveness of the process itself.

A final objective to be pursued concurrent with other program goals, but at a more modest rate, is the development or modification of processes that enhance the removal of metals and toxic organics. We will attempt to determine those operating conditions under which treatment plants can provide the maximum removal of contaminants. We will also seek to develop modifications to conventional and/or physical-chemical plants to achieve removals required to meet stream quality standards or standards for reuse at the lowest possible cost. (MD4, MD5, MD6)

Improving the Operation and Reliability of POTWs. Despite the billions of dollars spent on POTW construction, as many as 50 percent of the plants are not meeting anticipated performance goals, largely because of improper plant operation and deficiencies in plant design. EPA, therefore, is placing emphasis on improving the design, operation, reliability, and cost effectiveness of existing and future POTWs.

As many as 50 percent of the plants are not meeting anticipated performance goals.

To this end, our research program will study relationships between plant design, influent characteristics, operation and maintenance practices, facility management, and plant performance. Our work will help to pinpoint design deficiencies as well as facilitate the development of criteria for improved and cost-effective performance. Emerging treatment processes and techniques, land application systems (ME3), and alternative treatment technologies including energy utilization (ME1) will be considered.

We will also demonstrate the effectiveness of our Composite Correction Program (CCP) (ME4), a new approach for correcting operating deficiencies in POTWs. The CCP approach makes use of a comprehensive EPA plant performance evaluation to identify problems in all areas of plant operation. Remedial solutions through technical assistance, training, and follow-up monitoring and assistance are then recommended.

Improved automation of plant operations and methods of instrumentation will also be given attention. (ME2, ME5) Protocols or Measurement Assurance Programs (MAPs) that will detail purchase specification, procedures for bench acceptance testing, field installation, field acceptance testing, and required maintenance will be developed for families of instruments or sensors. Situations in which a given instrument should not be used will also be specified by MAPs.

Helping Small Communities Choose Treatment and Disposal Alternatives. Historically, most homeowners, public officials, and engineers have favored using public sewerage systems to deal with municipal wastewater. Despite significant advances in alternative technology development and new laws encouraging low-cost alternative technology in rural areas, treatment practices have remained largely unchanged. However, as costs of conventional sewerage and treatment for many small rural communities are being proven excessive on a per capita basis, lower-cost alternatives (e.g., pressure, vacuum, and small-diameter gravity systems) are being adopted, and today these individual or on-site treatment systems serve 29 percent of the nation's homes. EPA efforts are therefore being directed to the study of alternative on-site systems and the development of alternative low-cost centralized wastewater technology.

We will continue to provide information for upgrading and managing wastewater technology in small rural communities. (MF1, MF2, MF3, MF4) We will investigate cost-effective alternative systems and will develop practical handbooks for on-site and small community systems. The handbooks will discuss plant design, operation, and management, and will outline the comparative advantages and disadvantages of alternative systems. We will also study the possibility

We will investigate cost-effective alternative systems.

of modifying existing on-site systems. Additionally, we will begin examination of alternative systems for seasonal dwellings and commercial establishments. In this area, both unique problems and opportunities exist, and both will require the application of innovative technologies and management practices.

Finally, the program must anticipate the residential building technologies of the decade to come. We will need to work toward the development of wastewater systems in line with the energy-efficient nature of the dwellings future technologies will create.

Controlling Pollution from Urban Runoff. Though storm sewer discharges and combined sewer overflows are two of the most predominant forms of urban wastewater runoff, it has been only in the last 10 or 15 years that control of pollution from this runoff has been seen as significant.

Although urban runoff typically occurs for only brief periods, the discharge can result in a very large quantity of pollutants entering receiving waters. It has been estimated that on an annual basis, the discharge of oxygen-demanding materials from urban runoff can approximately equal the discharge of secondary effluent from dry weather facilities, and sediment discharge can exceed the sediment in dry weather discharge. In addition, during discharge, various amounts of nutrients and organic and inorganic toxic materials are released to receiving waters. The impact of all these materials on the receiving water, however, is clouded by the intermittent nature of the unban runoff discharges they are contained

WET WEATHER TREATMENT PLANT PERFORMANCE DATA

DEVICE	CONTROL ALTERNATIVES	DESIGN LOADING RATE (gpm/ft^2)	REMOVAL EFFICIENCY (%)	
			BOD_5	SS
PRIMARY	Swirl Concentrator	60	25-60	50
	Microstrainer	20	40-60	70
	High-Rate Filtration	24	60-80	90
	Dissolved Air	2.5	50-60	80
	Sedimentation	0.5	25-40	55
	Representative Performance		40	60
SECONDARY	Contact Stabilization		75-88	90
	Physical-Chemical		85-95	95
	Representative Performance		85	95

in. Harmful effects, it is thought, will likely be site specific, depending largely on the nature of the receiving water (MG2, MG8), with the most significant problems probably those posed by suspended solids and coliforms.

It has been estimated that the costs for controlling urban runoff using structural methods could be as high as $300 billion. To reduce the amount of capital required for control, EPA has investigated a variety of Best Management Practice alternatives. Each BMP offers a partial solution to runoff problems, and employs techniques such as improved surface sanitation (street sweeping), storage in the sewer system, control via chemicals, use of natural drainage and porous pavement (MG6), use of natural and man-made wetlands (MG7), sewer flushing (MG4), and erosion and sedimentation control (MG4). Many of the BMPs being considered control pollution at its source rather than at the end of the pipe. They offer multiple benefits of lower cost, earlier results, and improved and cleaner neighborhood environment. (The efficiency of various structural methods (MG3) that remove pollutants from urban runoff is shown in the table.)

The reduction of excessive flows through improved infiltration inflow control (MG5) and the proper disposal of sludge residues from wet weather control facilities (MG9) are also important areas of research.

Using Water That Has Been Treated. When the President established water conservation as the cornerstone of our future water resources policy, national attention was turned to water reuse. Advances in treatment technology, the need for alternate supplies to meet future water demands, and the impacts of short-term drought conditions on water supplies have also helped pique interest in reuse applications.

Defining treatment technology for potable use, however, is more difficult.

Currently, we can identify the treatment technology required for several reuse applications, among them agricultural, recreational, and industrial. For these applications, quality requirements have been partially, if not completely, defined. Defining treatment technology for potable use, however, is more difficult, since there is yet no consensus on the degree of treatment necessary to guarantee public safety. (See chapter 7, "Drinking Water.")

In addition to the potential health hazards posed, the high cost of processing wastewater for potable use has historically limited its appeal. Other water resources have generally been available at lower cost, and while this may have been due in the past to pricing below actual acquisition, treatment, and distribution costs, reuse today must compete on a true-cost basis.

Only about 25 percent of water used in the average home needs be of potable quality.

It is anticipated that when water is reused, high-quality water will not be used for a purpose that can tolerate a lesser degree of purity. This source substitution method allows conserving of approved sources of potable water by using poorer-quality water for such functions as toilet flushing and lawn watering, methods already employed in water-short areas. Since only about 25 percent of water used in the average home needs be of potable quality, i.e., for drinking, cooking, laundry, and bathing, the broadscale potential of source substitution to expand water reuse is significant. We will, therefore, work to explore the cost effectiveness of using multiple-distribution systems to deliver both potable and non-potable water.

Until more is known about the health effects of the residues found in high-quality wastewater treatment effluents, any potential reuse situation that poses health questions will not be sanctioned. To determine effects, we will implement long-term demonstrations investigating feasibility and practicability of reusing wastewaters for potable purposes. Evaluation studies of the potential for potable reuse have been funded in Denver, Colorado, (MH1, MH2, MH3) and Orange County, California (MH4). Additionally, short-term research will evalute new process alternatives to achieve low levels of organic residues.

Innovative and Alternative Technology (I&A). The municipal wastewater treatment program in FY 79 initiated a support effort to provide technical consultation and necessary technical manuals to support the I&A program's legislative authorities specified in the 1972 Clean Water Act and administered by the Office of Water Program Operations. This innovative and alternative technology program provides technical support to EPA Regional Offices and to the Office of Water Program Operations; it also functions as a major research arm of the overall municipal wastewater program. Recently, a technical advisory group made up of I&A and other municipal wastewater program personnel was formed to assist the Agency in meeting the requirements of the Clean Water Act. The Act charges EPA to encourage the construction and use of those innovative and alternative municipal treatment technologies that stress cost reduction, reclamation, energy conservation, and reuse. Additionally, the Act establishes a national goal that, during the three-year funding period ending in FY81, over 25 percent of the construction grant funds for new POTWs be used to build facilities that employ such I&A technology.

To this end, we will publish an updated Innovative and Alternative Design Manual (MI1), initiate field evaluations of I&A-approved projects (MI2), maintain a clearinghouse of program activities, and publish periodic progress reports (MI3). We will also evalute emerging technologies to determine whether they qualify as innovative and alternative technology. Additionally, design, performance, and cost data on novel aspects of I&A technology will be summarized, evaluated, and published for wide dissemination. Novel aspects could include the use of solar power, energy recovery schemes, biomass conversion technologies, by-product recovery alternatives, and aquaculture options.

Emergency Spills Research

Oil and hazardous substance spills occur as a result of accidents, equipment malfunction, human error, and deliberate discharge. Approximately 15,000 spills occur annually in the United States, contaminating the land, water, and air with noxious or toxic liquids, solids, and vapors. Spill results can be extensive property damage, death or personal injury from fire and explosion, or intake of toxic substances, the latter sometimes resulting in chronic effects such as increased incident rates of cancer or birth defects. Spills can render drinking water supplies unfit for human consumption, and can destroy coastal and inland aquatic food sources and make recreational areas unusable.

> Spills can render drinking water supplies unfit for human consumption.

Recognizing the potential for disastrous effects from spills, Congress addressed the problem by including Section 311 in the Federal Water Pollution Control Act (FWPCA) in 1972. Amended twice since then, Section 311 of the Act states that it is the policy of the United States to prohibit the discharge of oil and hazardous substances into United States waters. It assigns the responsibility of carrying out this mandate to EPA and the U.S. Coast Guard. By separate agreement, the Coast Guard has accepted responsibility for transportation-related spills on or adjacent to coastal waters and the Great Lakes while EPA has responsibility for spills on inland waters.

Under the mandate of the FWPCA and the

National Contingency Plan, EPA is required to perform three functions dealing with emergency spills:

- Promulgate regulations and guidelines for the designation, prevention, control, removal, and disposal of oil and hazardous substance spills;
- Provide enforcement of these regulations and the penalty provision of FWPCA;
- Provide On-Scene Coordinators (OSC), people specially trained and equipped to monitor and advise in control, removal, and disposal of spilled materials and in the restoration of areas damaged by the release of oil or designated hazardous substances.

The Resource Conservation and Recovery Act, Toxic Substances Control Act, and Safe Drinking Water Act also spell out specific EPA spills responsibilities.

Emergency Spills Research and Development Program

The emergency spills response research program primarily assists both industry and government by drafting guidelines and developing hardware and techniques for dealing with spills. The guidelines provide suggested methods for responding to, cleaning up, and mitigating the effects of spills. Additionally, ORD provides support at the scene of a spill by offering technical assistance personnel and special equipment for on-site response, clean-up, aerial surveillance, analytical support, and mitigation.

ORD provides support at the scene of a spill.

The development of new techniques and equipment has traditionally been an ORD function supporting the Agency's environmental protection programs. The new technologies provide technical data to support future regulations, and commercialization of these technologies is one objective of the emergency spills research and development program. The oil spill and hazardous substances spill program has an excellent record in this regard, having developed 17 major prototype systems for use at emergency spill sites, 7 of which are now commercially available.

There are two major objectives of the current spill program:

- To demonstrate technology and techniques for protecting the water, land, and air from accidental releases; and
- To identify environmentally sound methods for the disposal of contaminated wastes associated with clean-up operations.

The objectives are being pursued in six areas of emergency spill research and development:

- Prevention
- Notification and response
- Control and removal
- Ultimate disposal
- Fate and effects
- Restoration.

Each area has ongoing and planned research and development to fill the gaps in scientific data or control technology and techniques, helping to protect the public from the effects of spills. Within each area, the current research and development effort generally places a greater emphasis on hazardous substances spills than on oil spills.

Vital to the overall spills program is our comprehensive surveillance and analysis capability. This capability provides the foundation for all spill response research and development, beginning with prevention where it assists in contingency planning for a single potential spill site or for an entire watershed area, and ending with the analysis of final restoration activities; it is of incalculable value during the response to a spill situation for initial response assessment. Due to its value, ORD expects to continue technical support in this area and perform additional research and development to provide real-time surveillance capabilities using the Enviro-pod program. The Enviro-pod currently is operational with vertical and forward-looking normal and infrared aerial photograpic imagery.

EMERGENCY SPILL EQUIPMENT DEVELOPED BY ORD

- Mobile Physical/Chemical Treatment System—a trailer-mounted system for the treatment of contaminated water using granular-activated carbon (built by O.H. Materials, Inc., Findlay, OH.)
- Cyclic Colorimeter—capable of detecting heavy metals in water (marketed by Calspan Corp., Buffalo, NY).
- Hazardous Materials Detection Kit—designed to detect and monitor the location of chemical spills in water when the identity of the chemical is known (marketed by Hack Co., Ames IA).
- Organo-phosphate Pesticide Detection and Warning System—designed to detect and monitor for pesticides in water (manufactured by Midwest Research Institute, Kansas City, MO).
- Foam Dike System—capable of providing an "instant dike" from a portable backpack apparatus for the emergency containment of spilled hazardous substances (marketed by MSA Research Corp., Evans City, PA).
- Dynamic Inclined Plane Skimming System—a vessel for removing spilled oil from choppy harbor waters at 2 knot currents (marketed by J.B.F. Scientific Corp., Burlington, MA).
- Acoustic Emission Earth Dam Spill Alert Device—a passive device for determining the stability of earthen dams containing hazardous chemicals.
- Mobile Chemical Laboratory—contains a sophisticated complement of instruments (GC, IR, AA, etc.) for performing analyses at chemical emergency situations in remote field locations.
- Spill Assessment Laboratory—a mobile laboratory equipped to perform in-field treatability studies for cleanup of hazardous materials spills and industrial dump sites.
- Safety/Decontamination/Office Trailer—a mobile field office and safety station that provides office space for the EPA On-Scene Coordinator at a spill site, a storage location for safety and communications equipment, and an emergency shower for cleanup personnel.
- Mobile Stream Diversion System—a trailer-mounted pumping and piping system for the diversion (up to 3,000 feet) of small (up to 12.5 cfs) streams that have been contaminated by spills; isolates the contaminated segment of the stream to facilitate clean-up operations.
- Mobile Froth Flotation System—a trailer-mounted froth flotation system to clean oil-contaminated beach sand.
- Pump/Collection Bag System—a pallet-mounted emergency collection bag and pumping system consisting of a 7,000-gallon furled teflon-coated urethane bag and battery-powered or explosion-proof gasoline motor-driven pumps; temporarily stores spilled hazardous chemicals.
- Gelling Agent System—a trailer-mounted multipurpose gelling agent system for solidifying and immobilizing spilled hazardous liquids and preventing their penetration through the soil into groundwater supplies.
- Spill Alarm System—an in-stream warning system consisting of a number of individual probes and sensors (TOC, conductivity, UV absorption, etc.); for the continuous detection of a broad variety of spilled hazardous materials in water.
- Enviro-pod Aerial Monitoring and Surveillance System—a compact reconnaissance system designed to be secured to conventional aircraft to provide vertical and forward-looking photographic images of high resolution.
- Water Jet Boom System—a system capable of moving spilled oil horizontally relative to the water it floats on (even in the presence of waves) for either diverting the oil in high-water currents or increasing the effective encounter width of skimming equipment.

Spills Prevention. A portion of the ORD spills program is dedicated to the development of technology to reduce the number and severity of spill incidents. (SA2, SA4, SA5, SA6) The Department of Transportation has promulgated regulations directed toward the safe transportation of oil and hazardous materials. The EPA program will develop technologies and protocols for increasing safety at impoundment areas, plants, loading sites, and storage facilities. The Agency will also maintain close coordination with the

Department of Transportation to improve safety and reduce accidents during the transportation of oil and hazardous substances.

The output of the prevention portion of the spills program will be employed by manufacturers, users, transporters, and disposers of hazardous chemicals to select and install fail-safe level gauges, transfer lines, couplings, and seals, and will allow government and industry to more readily recognize spill-prone situations. Research will also provide the basis for mandated federal regulations on hazardous spills prevention. FY80-85 spills prevention research includes a progressive program to first statistically analyze historical spills data and then, utilizing the results of this analysis, develop and demonstrate fail-safe and cost-effective devices for the prevention of spills in the areas of greatest benefit. (SA4) The analysis will take into consideration not only the probability of future occurrences, but other aspects such as expected frequency, cause, volume, and cleanup cost as well. This effort is being coordinated with a review of current oil spill prevention regulations to determine their effectiveness. (SA3) Both engineering and procedural aspects of these regulations will be evaluated, and recommendations will be made for both new oil spill prevention techniques and for guidelines for improving prevention practices. Ultimately, study findings will be used in the preparation of revised oil spill prevention regulations.

Recommendations will be made for new oil spill prevention techniques.

The chemical manufacturing, transportation, and waste disposal industries will also be studied to determine which chemical and waste-handling technologies are the most cost-effective. (SA5) Results of this study will then be used to establish priorities for our development of prototype spill prevention techniques and equipment for these industries. (SA6)

In the specific area of pesticides application, ORD expects to complete (in FY80) a report on the prevention and control of spillage from both aerial and ground application. (SA1) This report will provide background for establishing guidelines for users of pesticides.

Overall, spill prevention research and development has the goal of providing EPA with the technical information necessary for the eventual promulgation of guidelines that establish a "standard of care" regarding spill prevention, control, removal, and site restoration.

Notification and Response. Past notification and response research and development has resulted in the development of commercially available detection and identification kits and personal protective clothing. Additional work is required to ensure that rapid notification and proper response can be made to any spill. Those who respond to hazardous materials spills, in particular, must have quick, accurate information on the nature of the spill and on the type of personal protection required. Experience shows that dependence on bills of lading and placards is frequently misleading and often dangerous. Work in the notification and response area is being closely coordinated with the Coast Guard.

A high priority of the notification and response program is the development and demonstration of protective equipment and safety devices for spill response personnel. (SB1) Equally important is the preparation of an emergency action manual for situation assessment, identification and detection of spilled material, confinement of spills, and control of air pollution. (SB2, SB3) This manual will be designed to enhance currently available manuals that deal almost exclusively with fire and explosion.

The longer-term program goals will be supported by two other efforts. The first will involve the development of computer models for spill plume movement. (SB4) These models will provide response personnel with the capability of predicting the movement of hazardous substances in air, surface water, and groundwater. The second effort will involve the development and demonstration of additional identification and detection devices including field kits and flow-through spill alarm systems.

Spills Control and Removal. Spills control and removal research and development develops and demonstrates equipment to clean up and remove spills of common oils, organic chemicals, toxic heavy metal salts, pesticides, and complex industrial wastes. The effectiveness and efficiency of spills control and removal equipment bears directly on the intensity and extent of a spill situation. The physical extent of the spill in turn relates directly to the number of individuals affected and the severity of the impact on human health and safety and on the environment.

The major focus of the research and development program is on the development of rapidly deployable, simple-to-operate equipment that will be effective in temporarily limiting the spread of spilled material. (SC2, SC5, SC7, SC9, SC10) Next in importance is the development of on-site technology for control and recovery of spilled hazardous substances. (SC1, SC5) This technology serves a double purpose, directly enhancing the cost effectiveness of cleanup operations while decreasing the dangers posed by transport; objectives are reached by providing an on-site capability for the reclamation, detoxification, or destruction of oil and hazardous substances.

> The major focus is on the development of rapidly deployable, simple-to-operate equipment.

A third part of the spill control and removal research and development program deals with the problem of air pollution control in the event of spills of gases or volatile hazardous substances, a major concern of public health and safety officials. ORD is preparing emergency manuals to provide air pollution control guidance for the first personnel at the scene of a spill. (SC3) These manuals will supplement currently available manuals with information on the best operational practices and the best available equipment and techniques for retarding the rate of transfer of spilled material to the open air and for inhibiting the flow of ground-hugging toxic and flammable vapors.

> Present methods require extensive use of manpower and equipment.

Shoreline protection and restoration is another aspect of the spills control and removal program. (SC8) Despite continuing efforts to the contrary, most offshore spills result in significant shoreline contamination involving environmental insults to estuarine, ocean, and inland areas having recreational, esthetic, or commercial value. The state of the art for the cleanup of shorelines is primitive. Present methods require extensive use of manpower and equipment that in some cases can be more environmentally damaging to the shoreline than to the spilled material itself. A major technical development effort is needed to address this problem.

The final aspect of the spills control and removal program is operation of the Oil and Hazardous Materials Simulated Environmental Test Tank (OHMSETT) facility to test and evaluate new equipment and techniques as they are developed. Of major concern at this time is the testing and evaluation of chemical and biological agents that are preintended for use under conditions where present mechanical clean-up technology is not adequate, or where mechanical cleanup would be more damaging to the environment than no cleanup at all.

Ultimate Disposal of Spills Residue. The fourth area of research and development deals with the ultimate disposal of recovered spill residues. Although recycling of these residues is the most desirable method of disposal, it is not always technically or economically feasible. The program is thus geared to the development of a number of innovative alternatives to residue disposal. These are:

- Conversion of refractory organics to carbon dioxide, water, salts, etc.;
- Immobilization of toxic constituents so that they present no greater leaching hazard than they do in natural rock or mineral formations; and
- Application of sophisticated degradative microorganisms and nutrients.

The decision to focus on these specific techniques is based on a previously prepared assessment of various hazardous substances disposal alternatives. Candidate techniques will be investigated at the bench and pilot scale where transportable and mobile disposal systems will be developed for on-site detoxification/destruction of concentrated residuals from spill cleanup operations. (SD1) The most promising techniques will then be further refined and demonstrated as full-scale prototypes. (SD2)

Fate and Effects of Spills. In fate and effects research, ORD is studying the ecological effects of acute discharges of hazardous substances. (SE1, SE2, SE3) All those who respond to, clean up, and dispose of spills of hazardous materials face the problem of determining what will happen to the environment if cleanup is imperfect and/or if nature alone takes its course, without active cleanup action. The thrust of the research and development effort is to determine when nature can cope with the spill or when spill by-products and degradation present short- or long-term hazards that must be addressed. This information is also essential for determining when sufficient cleanup has been accomplished.

Restoration of Spills Environment. Federal, state, and local officials need procedures to first assess the extent of spill damage and its impact on human health and the environment and then restore the spill environment through removal operations and by enlisting the aid of natural processes such as accelerated microbial degradation. The restoration of spills environment area of the research and development program concentrates on the assessment/restoration decision-making process (SF1) and on the development and field testing of experimental restoration techniques and prototype equipment. (SF2)

INDUSTRIAL WASTEWATER RESEARCH PLAN

PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
Industrial Source Characterization and Assessment	Up-date characterization for "21 industries, 129 pollutants," including the following industries: organic chemicals, iron and steel, non-ferrous metals, petroleum refining, petroleum chemicals and coal-fired power plants **IA1, B6** Multimedia assessments of coal gasification and liquefaction, coal cleaning, advanced oil and gas production and recovery, and alternative energy conserving industrial processes **IA2** Provide data back-up for pretreatment regulations **IA3** Assess fuel grade alcohol production (for gasohol) **IA4** Effluent characterizations of various waste-to-energy processes **IA5**	Characterize hazardous organics in the effluent of a petroleum refining complex **IA8** Characterize mining wastewaters and assess impacts of surface mining regrading procedures **IA9** Environmental assessment of *in-situ* coal gasification and atmospheric and pressurized fluid bed combustion **IA10** Assess western geothermal brine disposal options **IA11** Characterize industrial discharges from additional industries for other toxic pollutants. **IA12**	Complete data base on pesticides intermediates and their control **IA13** Complete data base for development of pesticides effluent guidelines not included in 1983 regulations **IA14** Quantify magnitude of water-quality limited problems and identify limiting parameters **IA15** Reassess impacts of conventional pollutants industry **IA16** Assess additional geothermal brine disposal options, including ocean disposal (continuing through FY 83) **IA17** Characterize and assess wastewaters from technologies using energy conserving or less polluting process or production modifications **IA18**	Compare cost effectiveness of combinations of technology-based and ambient water-quality-based control strategies **IA21** Assess new technologies with high potential for groundwater impacts, e.g., solution mining of uranium **IA22**	Evaluate new processes developed to utilize non-petroleum-based feedstocks or to otherwise conserve energy resources **IA23** Define effluent characteristics of new manufacturing methods developed to meet new markets and to comply with energy and materials limitations **IA24** Characterize and assess industry with increased consideration for socioeconomic and cost-benefit factors **IA25**

PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
	Assessments at various oil shale retorting sites (continuing through FY 81) **IA6** Identify potential cross-media impacts of wastewater treatment (continuing) **IA7**		Characterize and assess modified manufacturing processes, emerging industries, and new technologies (continuing) **IA19** Initiate broad use of bioassy techniques for characterization of industrial effluents **IA20**		
Treatability	Determine treatability of "129 priority pollutants" by conventional and advanced technology (with Municipal Program) **IB1** Determine treatability of pesticides and their intermediates where data are not available (contuing through FY 82) **IB2** Expand treatability data base **IB3** Issue treatability manual containing treatability data on numerous compounds, operational data on industrial control facilities and design data on control technologies **IB4** Publish pollution control guidance on low-Btu coal gasification and direct coal liquefaction; preliminary guidance on fuel grade alcohol production (for gasohol) **IB5** Establish quick-response capability for provision of new treatability data **IB6**	Publish pollution control guidance on oil shale conversion and on atmospheric and pressurized fluid bed combustion **IB7** Issue pollution control guidance on fuel-grade alcohol production (for gasohol) **IB8** Identify control needs currently technologically or economically unattainable **IB9** Determine treatability of newly recognized toxic pollutants **IB10** Identify additional indicators/surrogates for measures of treatability (continuing) **IB11** Maintain and update treatability data base (continuing) **IB12** Analyze, classify, and correlate treatability data aimed at improving ability to predict removals for stricter standards and/or newly recognized pollutants (continuing) **IB13**	Publish revised geothermal pollution control guidance **IB14** Publish additional pollution control guidance as appropriate (continuing) **IB15** Initiate work on revising the treatability manual **IB16** Explore basic mechanisms of removability in most important treatment process (continuing) **IB17**	Determine treatability of conventional pollutants to higher levels of removal **IB18** Compile treatability data from reuse/recycle applications and demonstrations (continuing) **IB19** Issue a revised treatability manual **IB20**	Determine treatability of compounds generated from processing non-petroleum-based feedstocks and from emerging industries **IB21** Increase emphasis on "toxicity" bioassys for evaluation of treatability **IB22** Correlate treatability data to allow predictive modelling of treatment technologies **IB23**

INDUSTRIAL WASTEWATER RESEARCH PLAN

PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
Treatment Technology and Non-Treatment Alternatives	Evaluate control methods for "129" pollutants for the chemical process industries to achieve required control at reasonable cost and energy use **IC1** Examine foreign iron and steel and copper-lead smelting wastewater control technologies for possible transfer to the United States **IC2** Assess management methods for sedimentation ponds used in the mining industry **IC3** Demonstrate disposal of geothermal brines to waterfowl wetlands **IC4** Identify potential energy-saving industrial wastewater treatment alternatives **IC5** Evaluate pilot wastewater control technologies for waste-to-energy processes (continuing through FY 81) **IC6** Develop pretreatment control strategies and methods (continuing) **IC7**	Identify control alternatives for economically marginal industries **IC8** Submit recommendations on BMP's for strip mining of coal and for mining of phosphate, uranium, and conventional metals **IC9** Conduct laboratory/bench scale development/ evlauations of conventional treatment for resistant synfuels wastewaters **IC10** Develop/demonstrate improved biological and physical-chemical treatment technologies (continuing) **IC11**	Demonstrate centralized treatment of metal finishing wastes **IC12** Develop bench/pilot-scale textile wastewater control technology to support 1983 guidelines, including nonconventional pollutants and pretreatment regulations **IC13** Evaluate semi-works scale wastewater control technology for oil shale retorting (continuing through FY 84) **IC14** Laboratory/bench scale development of innovative control technologies for synfuels wastewaters **IC15** Evaluate pilot-scale treatment of synfuels wastewaters **IC16** Evaluate non-treatment alternatives (continuing) **IC17**	Demonstrate additional applications of centralized industrial treatment **IC18** Evaluate and develop advanced separations technology (continuing) **IC19** Submit recommendations on BMP's for additional industries **IC20**	Demonstrate advanced separation and treatment technology for high pollutant removals **IC21** Determine the relative roles of treatment and non-treatment alternatives **IC22** Demonstrate joint EPA-industry non-treatment alternatives **IC23** Develop technologies for chemical modification of hazardous wastes for pollution control and resource recovery **IC24** Model non-treatment alternatives for detailed evaluation of environmental benefits and economic incentives **IC25**

PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
Recycle/Reuse	Develop recycle/reuse concept for fiberglass textile industry **ID1** Evaluate metal finishing wastewater recycle system **ID2** Develop laboratory/pilot scale recycle/reuse technique for ash slucing systems at power plants **ID3** Collect data on water use and analysis of industrial recycle/reuse applications (continuing) **ID4**	Demonstrate recycle/reuse for targeted industries, such as food processing organic chemicals, iron and steel and textiles **ID5** Demonstrate hyperfiltration of textile dyeing wastewaters for reclaiming water, chemicals and energy **ID6** Compile cost comparisons between recycle/reuse and effluent treatment (continuing) **ID7** Determine renovated water quality requirements for recycle/reuse purposes (continuing) **ID8**	Demonstrate recycle/reuse for second tier of industries with high potential to solve toxic discharge problems through recycle/reuse **ID9** Examine various recycle/reuse technologies to determine factors inhibiting commercialization **ID10**	Demonstrate recycle/reuse for next priority industries **ID11** Develop recommendations on industries that could achieve zero discharge through adoption of recycle/reuse **ID12**	Assess industrial recycle/reuse to alleviate water supply shortages **ID13** Develop improved industrial recycle/reuse technologies **ID14** Update user's manual for industrial recycle/reuse **ID15**

MUNICIPAL WASTEWATER RESEARCH PLAN

PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
Municipal Wastewater Treatment Processes	Demonstrate full scale ultra-violet light disinfection **MA1** Design manual of lagoon upgrading techniques **MA2** Publish assessment on health effects associated with microbial aerosols from activated sludge plants **MA3**	Demonstrate ozone disinfection of 200 FC/100 ml Standard. **MA4** Field evaluate activated biofiltration system **MA5**	Field evaluate deep shaft aeration technique **MA6**	Evaluate Bardenpho Process **MA7** Evluate field scale of new generation high efficiency submerged aeration equipment **MA8**	Evlauate full scale fluidized bed carbonaceous removal **MA9**

MUNICIPAL WASTEWATER RESEARCH PLAN

PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
Land Treatment and Aquaculture	Summary report of existing land treatment system studies **MB1** Evaluate effectiveness of an introduced fish species in wastewater treatment aquaculture system **MB2**	SOTA design report on overland flow system **MB3** Preliminary design criteria for water hyacinth municipal waste treatment **MB4**	Develop nitrogen management model for slow rate and rapid infiltration system **MB5** Report on evaluation of water hyacinth harvesting and utilization for composting and biogas conversion **MB6**		Assess health effects associated wth microbial aerosols from spray irrigation systems **MB7** Report transport transformation of toxic substances through soil treatment system **MB8** Assess treatment effectiveness of artificial wetlands for treatment and managing municipal wastewaters **MB9**
Sludge Processing, Use and Disposal	Design manual for sludge treatment and disposal **MC1** Market study of non-food crop sludge utilization **MC2**	Evaluate within-vessel composting **MC3** Evaluate producing road aggregate from sludge and refuse incinerator ash **MC4**	Determine feasibility of producing synthetic asphalt from liquefaction of sludge **MC5** Design manual for sludge utilization on the land for food crops **MC6** Demonstrate use of turbine using digester gas to meet plant energy requirements **MC7** Update of health risks associated with land application of municipal sludge **MC8**	Field evaluate composting on a barge **MC9** Evaluate advanced techniques for controlling emissions from thermal conversion process **MC10**	Begin evaluating operation of synthetic asphalt from sludge liquefaction **MC11** Evaluate plant uptake and accumulation of toxic organics **MC12** Demonstrate using sludge to produce a valuable non-food crop **MC13**

PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
Toxic Control	Determine treatability of all non-carcinogenic priority organic pollutants **MD1**	Priority pollution removability studies at 25 POTWs **MD2** Treatability studies of carcinogenic priority pollutants **MD3**	Evaluate toxic metal stripper **MD4** Evaluate ozone/carbon adsorption for toxics removal **MD5**		Evaluate UV/ozone for disinfection and trace toxic organic control **MD6**
Improving Operation and Reliability of POTW's	Produce an energy assessment procedures manual **ME1** Initiate SOTA on application of computer technology to control POTWs **ME2**	Determine operating and maintenance practices and problems related to land treatment **ME3**	Complete state-wide implementation of composite correction program **ME4** Complete SOTA on computer control of POTWs **ME5**		
Small Community Treatment Alternatives	Guidelines for community-wide managememt of on-site wastewater systems **MF1**	Determine toxics associated with on-site systems **MF2**	Publish septage management handbook **MF3**	Evaluate best techniques for rural community cost-effectiveness and development of management system **MF4**	
Urban Runoff	Evaluate sewer flushing as low cost non-structural CSO control method **MG1** Conference on urban stormwater and CSO impacts on receiving waters **MG2**	Evaluate CSO control with SWIRL regulator/separator and with discoscreen/disinfection **MG3** Evaluate alternative best management practice for CSO abatement **MG4** Evaluate insituform remediation of infiltration/inflow problems **MG5**	Evaluate new porous pavement concepts **MG6** Evaluate feasibility of utilizing marshland for urban runoff control **MG7** Field-verify unsteady state dissolved oxygen impact of urban runoff on receiving stream **MG8**		Evaluate land disposal of sludges from wet weather control facilities **MG9**

MUNICIPAL WASTEWATER RESEARCH PLAN

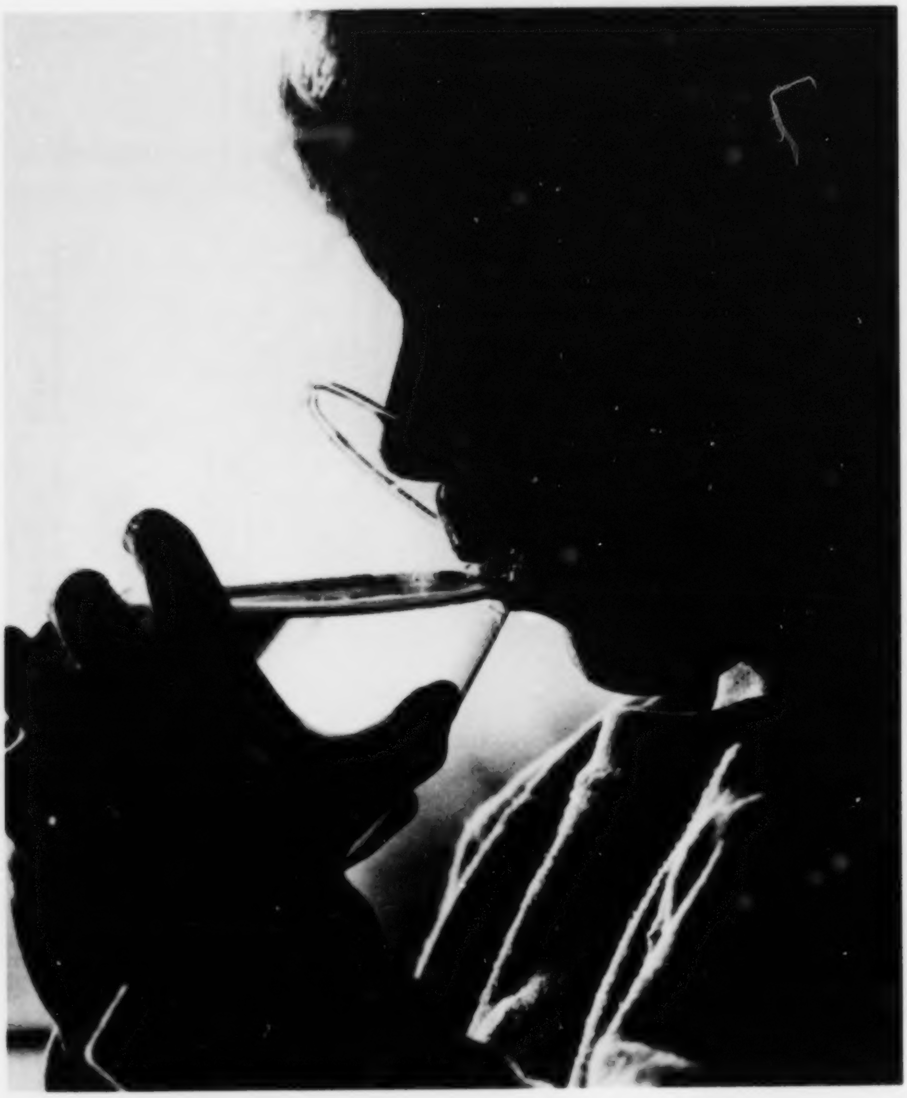
PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
Reuse				Complete construction, shakedown and initiate stable operation of 1 MGD potable reuse evaluation facility **MH1** Begin animal feeding experiment related to potable reuse evaluation **MH2**	Complete interim report on potable evaluation facility product water quality **MH3** Compile animal health effects studies using reclaimed effluents from Water Factory 21 **MH4**
Innovative and Alternative Technologies I&A	Update innovative and alternative design manual **MI1**	Initiate field evaluation of I&A approved projects **MI2**	Publish evaluation report on I&A program in meeting national goals **MI3**		

EMERGENCY SPILLS RESEARCH PLAN

PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
Prevention	Prevention and control of spills from pesticide application **SA1**	Statistical analysis of spills **SA2** Evaluate effectiveness of SPCC regulations **SA3**	Develop/evaluate fail-safe devices **SA4** Risk analysis of chemical industry **SA5**	Develop spill prevention techniques and equipment **SA6**	
Notification and Response		Develop/evaluate personnel safety devices **SB1** Prepare emergency action manual **SB2**	Spills identification and detection **SB3**	Prepare emergency action manual **SB2**	Model spill plume movement **SB4**

PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
Control and Removal	Evaluate systems for treating soils **SC1**	Organize national conference on the control of oil spills **SC5**	Organize national conference on control of hazardous materials spills **SC4**	Evaluate second generation containment systems in water courses **SC6**	Evaluate second generation containment systems on land **SC9**
	Develop/evaluate systems for separating substance from water **SC2**			Prepare user manuals for spills control equipment and techniques **SC7**	Develop second generation instream treatment systems **SC10**
	Develop/evaluate systems for mitigation of air pollution **SC3**			Develop new technology for shoreline protection and restoration **SC8**	Develop/evaluate systems for mitigation of air pollution **SC3**
	Organize national conference on control of hazardous material spills **SC4**			Organize national conference on the control of oil spills **SC5**	Organize national conference on control of hazardous materials spills **SC4**
Ultimate Disposal			Investigate mobile disposal systems for on-site detoxification of residuals **SD1**		Develop/evaluate most promising techniques **SD2**
Fate and Effects		Identify data gaps for hazardous substances **SE1**	Determine effects and persistency data **SE2**		
Restoration	Identify gaps in knowledge on accelerated recovery of spills areas **SF1**		Develop/evaluate restoration techniques **SF2**	Prepare restoration manual **SF3**	

DRINKING WATER



Our drinking water can contain a number of contaminants. EPA conducts research to improve drinking water quality and to prevent groundwater pollution.

People who live or travel in certain foreign countries are familiar with the unpleasant and sometimes painful problems that can result from unsafe drinking water there. In the United States, however, most of us scarcely give our drinking water a thought, believing that we can depend on its purity. Usually, we can. But our move from a rural agricultural society to an urban industrial one has changed the nature of our drinking water, particularly with respect to organic contaminants, and this change, together with our improved analytical and health assessment methods, has resulted in an increased concern over drinking water quality. Of note:

- A 1969 community water supply study estimated that 8 million people were being served potentially dangerous water from perhaps 5,000 community water supply systems. The study revealed problems with equipment design, construction, condition of basic water treatment plants and training and experience of plant operators. Overall, smaller systems were found to have more problems than larger ones. These 1969 findings were supportd by later studies.
- Studies begun in 1970 of public water supply systems in 13 states showed that many systems did not meet bacteriological standards during one or more of the months in the 12-month period prior to the studies. A number of systems did not meet standards during surveillance while others were shown to require either additional treatment facilities or significant modifications in their operation.
- EPA is currently analyzing data on public water supply systems reported by states. This will measure the degree of compliance with standards.

The need for national drinking water standards had been discussed for many years prior to these studies. Then, in the early 1970s the debate was focused by the detection of asbestos fibers in the Duluth, Minnesota, water supply system, and by the discovery that the New Orleans water supply system contained 66 organic chemicals.

In December 1974, the Safe Drinking Water Act was passed. Since that time, the major research emphasis has been on the problems of organic and inorganic chemicals in drinking water. As we move into the 1980s, a major effort will be made to further define and deal with the problems of organic contaminants.

The Tools to Ensure Safe Drinking Water: Future Approaches

Safe drinking water is primarily the responsibility of state and local governments; however, through the Safe Drinking Water Act and other legislation, Congress has directed that the federal government accept responsibility as well by developing and promulgating national drinking water standards and by implementing a national drinking water and groundwater program. These standards specify the maximum permissible contaminant levels (MCL) necessary to protect public health and welfare. The drinking water standards are of particular concern to us because of their tie-in to other serious issues facing EPA today. These include the defining of hazardous wastes, setting criteria for land treatment and reuse projects, and setting criteria and standards for water quality and groundwater contamination.

Since 1977, interim primary drinking water regulations covering bacteria, turbidity, inorganic chemicals, radionuclides, and certain pesticides have been in effect. Soon these standards will be supplemented with regulations to limit the amounts of chloroform, other trihalomethanes, and synthetic organic chemicals in drinking water. In the near future, EPA will concentrate on development of additional MCLs for specific organic carcinogens such as carbon tetrachloride and trichloroethylene, and on revision of existing standards to incorporate new data. We also plan to develop and define methods to control

Groundwater pollution will receive significant emphasis.

harmful inorganic contaminants—especially those that may increase the incidence of cardiovascular disease—and to assess effects of direct or indirect additives to drinking water. Groundwater pollution will receive significant emphasis through studies that will designate sole source aquifers. Recently proposed underground injection control regulations may also require research to assure protection of our groundwater supplies.

Research for Improving Drinking Water Quality and Preventing Groundwater Deterioration

EPA conducts research to enhance the scientific and technical foundations underlying National Drinking Water Regulations and regulations that protect groundwater quality. The objectives of our research are to:

- Identify substances that occur in drinking water supplies at a sufficient number of locations to warrant regulations.
- Define drinking water contamination effects on human health.
- Establish analytical procedures to monitor contaminants.
- Describe changes in treatment processes or new treatment technologies that are required to minimize contaminant formation or reduce concentration levels.

The contaminants under study fall into four categories: organic, inorganic (including asbestos), microbiological, and those affecting groundwater.

Organic Contaminants

A tremendous number of organic compounds can find their way into drinking water. Over 900 of these compounds have been identified at concentrations greater than 1 part per trillion. To adequately support decisions on organic contaminants, our research program is designed to provide methods to detect, identify, and monitor organic compounds. (A3, A4, A8, A14, A17, A20). The program is also designed to provide tools to determine health impacts from contaminants and methods to control contaminants and the byproducts they may form during treatment.

Work in the development of analysis methods to identify and measure pollutants in drinking water is coordinated with similar efforts being carried out for wastewater programs and to support water quality decisions (see Chapters 5 and 6). In the future, we will emphasize development of analytical methods to concentrate, isolate, and characterize non-volatile organic substances. These techniques will assist us in arriving at general conclusions about the toxicity of such compounds. Methods to isolate non-halogenated products such as epoxide and quinones will be developed as well. These substances may be formed by reactions of disinfectants with organic substances already in water.

A Master Analytic Scheme will be supported by our research. The scheme will allow broader exposure assessment studies and, subsequently, detection of organic compounds which we cannot now measure.

Quality assurance will be promoted.

Quality assurance will be promoted through standardized monitoring methods and by supplying workers in the field with standard samples and pertinent reference materials. We will continue to validate our analysis methods, with particular emphasis placed on those methods used to analyze synthetic organic chemicals. Alternate test procedures to measure MCL contaminants will also be developed and evaluated. (A21)

Two types of organic compounds still elude identification and measurement by gas chromatography-mass spectrometry: those that are non-volatile and thus will not pass through the chromatograph, and those whose mass spectral "fingerprints" are not on file. We will work to develop techniques to identify and measure non-volatile compounds and those compounds that cannot be identified by mass spectral matching.

Our research into organic contaminants of drinking water will focus on their carcinogenic effects with attention given to mutagenic and teratogenic effects. The bulk of the work will involve the suitable preparation of organic concentrates for testing and the subsequent identification of biologically active fractions. Key compounds will then receive long-term toxicologic study. (A5, A6, A9, A10)

Human health data will be collected from a variety of epidemiological studies, starting with those communities where the occurrence of cancer exceeds expected rates. Drinking water quality in these and other communities will be defined by both chemical analysis methods and screening tests. Health risks can be derived from these epidemiological, chemical, and toxicologic findings and guidelines for limiting the amounts of several chemicals in drinking water can be established.

In order to identify any measurable increased risk of disease, EPA will also study populations whose drinking water is contaminated by only a few identified synthetic organic compounds. The study will be accomplished with the use of some novel approaches, and will provide valuable data on the human health effects of long-term exposure to environmental contaminants. We will also compare the incidence of disease in various populations which have drinking water similar in trihalomethane concentrations but disimilar in non-trihalomethane organics. These studies will produce estimates of risks associated with the non-trihalomethane organics. (A1, A11, A12)

Further efforts will develop bioassay procedures that point to specific health effects risks and that may be used for drinking water monitoring. Since current test systems such as the Ames test may not be sensitive enough for use with unconcentrated waters and may produce questionable quantitative and qualitative relationships to human health risks, we will give serious consideration to the development and modification of bioassay methods capable of characterizing the hazards found in drinking water supplies. After the methods are developed, standardized, and applied, these short term *in vivo* assays may be used in place of the detailed chemical analyses that would otherwise be required if maximum contaminant levels were established for individual compounds. (A15, A18)

The Ames test may not be sensitive enough.

Short term *in vivo* assays are presently in use to test water from 15 American cities and from pilot plants studying alternate treatment techniques. We will attempt to adapt the assays to detect carcinogenic and mutagenic drinking water hazards. Successful adaptation will have definite advantages over current *in vitro* tests.

One epidemiological study indicates possible significant associations between drinking water quality and birth defects.

The possibility that drinking water contamination may cause birth defects will also be investigated. Although past EPA laboratory studies of drinking water concentrates found no teratogenic effects, one epidemiological study indicates possible significant associations between drinking water quality and birth defects. We will undertake further epidemiological studies to determine if any constituents of drinking water are associated with birth defects and whether the relationship is causal. The studies will include both organic and inorganic contaminants.

Reducing Organic Contaminants and Controlling By-Products of Treatment. Various surveys have shown that certain organic compounds retain their form through rivers, reservoirs, treatment, and distribution systems. They also demonstrated that other organic compounds formed or added during water treatment are equally persistent. However, data from pilot plant activities and modular- and full-scale field evaluations have demonstrated that by modifying disinfection/chlorination and treatment practices, a considerable reduction in certain organic chlorination by-products can be attained. Currently under study are the organic halogen (OX) compounds that occur widely where chlorination is practiced. Research will concentrate on the influence that environmental factors such as precursor concentration, disinfectant dose, temperature, pH, and time have on the rate and quantity of OX material formed. (A2) In addition, large-scale pilot plant and full-scale plant projects are planned to study the fate of various organics, not only during water treatment but throughout the entire system—from reservoir to tap. The objective of the projects will be to provide more economical and efficient treatment methods. The research will focus on optimizing the removal of disinfectant by-product precursors through the use of various unit processes such as coagulation and bioxidation.

Field-scale research projects will be conducted in cooperation with utilities and local and state governments to determine how effectively and at what cost certain in-place experimental treatment processes remove specific environmental contaminants. We plan to evaluate existing, in-place unit processes such as coagulation, granular activated carbon beds, powdered activated carbon, polymetric resins, ozonation, aeration, ozonation/ultraviolet (0_3/UV), oxidation plus adsorption, and chlorine dioxide. (A7, A13, A16, A20) Emphasis will be on large-scale (modular) experimental applications of control technology in support of proposed amendments to the Interim Primary Regulations for organic chemicals, as well as on contemplated revised MCLs.

The studies' results will facilitate our ability to prudently prescribe water treatment.

These field-scale research projects on systems already in-place are necessary to determine how existing technologies will perform under actual operating conditions. Furthermore, the studies' results will facilitate our ability to prudently prescribe water treatment when any health risk from organics is suggested and monitoring is not practical.

Inorganic Contaminants

A number of inorganic constituents including nitrates, metals, radionuclides, and asbestos have been found in tap water in the United States. Epidemiological studies have suggested that small concentrations of inorganics in drinking water may significantly relate to cardiovascular disease. Our research program is designed to locate and measure inorganic pollutants, study their health impacts and evaluate means to control their occurrence in drinking water. (B1, B2, B4) Methods for analyzing inorganics need to be improved and we will work toward this. We will develop analytical methods for species of inorganics, improve our multielement analysis capabilities, and work to develop real-time inorganic monitoring devices. (B21, B27, B30)

Studies will also estimate human exposure to radioactive nuclides by determining the occurrence of radon and radioactive nuclides in drinking water. To provide a basis for reevaluating drinking water standards, water samples will be analyzed for radium 226, radium 228, gross alpha and gross beta activity, tritium, strontium 90, and radon. (B9)

Polyvinyl chloride (PVC) pipe is commonly used for transmitting potable water. During the PVC manufacturing process, however, various organotin compounds are used as stabilizers. We need to develop methods to identify and measure these compounds in drinking water. Similarly, polynuclear aromatic hydrocarbons (PAHs) can occur in drinking water from some coatings on metal pipes. Our research will determine the contribution this source makes to finished water PAH concentrations.

Effluents from advanced wastewater

treatment plants will also be analyzed to determine the efficiency of tertiary treatment for removing trace elements of inorganics. (B3) To ensure accurate asbestos fiber counts, we are attempting to improve collection, shipping, storage, and preparation of water samples. (B7, B14)

Health Impacts — Inorganics. Past studies have revealed a potential link between cardiovascular disease and drinking water. To date, however, most of the epidemiological studies suggesting this link have been rather broad in nature, concentrating more on geographical areas than on the health histories of specific individuals. Thus, there is a need to further evaluate other known cardiovascular risk factors such as smoking, family history, exercise, and diet in relation to drinking water quality data. We will thus initiate a prospective study of cardiovascular disease in a group of middle-aged men. Tap water used by the participants will be characterized for some 80 elements, but physical exams, interviews and laboratory tests will also be included to establish other cardiovascular disease risk factors. The results of this study will enable identification of any critical elements in the water and will allow for a precise quantification of the degree of risk such elements present in conjunction with other known non-water risk factors. If drinking water elements are causally implicated, the National Research Council estimates that optional conditioning of drinking water could reduce the annual cardiovascular disease mortality rate by as much as 15 percent in the United States, thereby saving an estimated 150,000 lives per year. (B19)

> We will continue toxicologic studies on lead to determine whether central nervous system development may be hampered.

Other epidemiological studies are planned to establish the relationship between cardiovascular disease — particularly hypertension — and sodium and 35 other inorganic contaminants that may occur in drinking water. Long-term toxicologic studies will also be initiated to determine the impact that various combinations of barium, calcium, magnesium, lead, cadmium, and sodium in water have on cardiovascular disease development. (B10, B11, B16, B17, B22, B23, B28)

Other adverse health effects linked to the inorganic contaminants of drinking water will also be studied. We will continue toxicologic studies on lead to determine whether central nervous system development may be hampered by what are considered today to be normal human blood lead levels. The bioavailability of certain metals — including lead—in hard and soft waters and in food will be compared, and safe levels will be determined. (B18)

Asbestos is an inorganic of particular concern because it is a possible carcinogen and co-carcinogen. Studies will determine whether asbestos from mining operations, asbestos-cement water pipes, and natural erosion contributes to increased cancer rates. We also plan to sponsor some small short-term animal experiments to examine the effects of various asbestos fiber lengths and to explore the causal mechanisms which may determine the potential of asbestos to be a co-carcinogen. (B15)

Certain inorganic, organic, or microbiological contaminants of drinking water will also be studied to determine if an association exists between them and neurologic diseases such as multiple sclerosis. Metallic toxins and viruses are considered by some researchers to be possible predisposing factors for some of these chronic diseases. Protocols for the evaluation of additives used in treatment of drinking water will also be developed.

Controlling Inorganics. Treating water for the removal of inorganics can present a technological problem, particularly for small communities. To alleviate this problem, EPA will improve treatment technologies. Our effort will include investigations of those polymers that may be used to improve coagulation or filtration as well as those that soften water to reduce radium, iron, manganese, and calcium. Bench and pilot-level studies will examine a number of treatments and processes for their effectiveness in removing arsenic, barium, cadmium, chromium, fluoride, lead, mercury, nitrate-nitrogen, and selenium and radionuclides. (B5, B6) These studies will consider removal via:

- conventional water treatment processes of alum and iron coagulation
- lime and excess lime softening
- powdered and granular activated carbon
- ion exchange
- activated alumina treatment
- reverse osmosis

Our work will focus on applying technology to small communities. Several studies will develop design, operating, and economic data for technologies capable of removing one or a combination of contaminants from a variety of source waters. (B12) Field testing and cost analysis of in-place full-scale facilities will be a necessary aspect of this future work. We will also examine existing package plant systems being used by small communities to determine the effectiveness of the systems in removing contaminants from a variety of surface waters; a technical evaluation of the package plants will be provided to allow more widespread application of effective systems by small utilities. Methods to minimize costs of successful treatment technologies will be emphasized (B20, B24, B25, B26), and evaluations of home treatment devices are planned. Finally, we will identify critical water stabilization factors and will develop cost-effective treatment methods to prevent corrosion of metal pipes. (B13)

Our work will focus on applying technology to small communities.

Microbial Contaminants

Chlorination has been the primary method used in this country to destroy microbes in drinking water. But, though this disinfection process has proved to be highy successful in reducing waterborne disease, we are still concerned about the microbiological contaminants in drinking water, particularly in light of the use of alternate disinfectants and possible changes in treatment processes. (C2, C11) Our concern has been deepened by the discovery of disinfectant-resistant pathogens and by the fact that in widespread areas of America only limited treatment is applied to purify water.

In cooperation with the Center for Disease Control, outbreaks of waterborne infectious diseases will be investigated to identify the etiological agents in water, to determine their route of entry, and to recommend corrective action to prevent recurrence. (C1) Particular attention will be paid to the role played by exotic or newly identified bacterial agents of gastroenteritis, e.g., *Aeromonas, Campylobacter, Yersinia,* and *Legionella,* as well as to viral and parasitic agents. We will also continue to study the parasite *Giardia* to determine its occurrence in and route of transmission to man. Data from these studies and from investigations of the efficiency of various treatment processes for deactivation or removal of the agents will be used in recommending control methods to break the disease cycle. (C4, C8, C13, C14, C15) Current studies will be expanded to investigate the health significance of *Giardia* in surface waters that have received minimal or no treatments, and *Giardia* cysts that occur in wild animals inhabiting watersheds. Epidemiological studies to determine the incidence of giardiasis in those who consume contaminated waters will also be initiated. (C7, C9)

Water quality monitoring is an ongoing process.

Water quality monitoring is an ongoing process but the traditional concept of determining water quality by measuring indicator organisms rather than specific pathogens is frequently challenged. We will therefore evaluate the efficacy of the standard coliform test and investigate the possibility of using other indicators. We will also continue to improve microbiological sampling procedures and analytical methods for both indicator organisms and pathogens, including viruses and protozoans. (C5, C6, C10)

Pilot and field-scale studies will determine whether changes in treatment processes bring about new microbiological problems. These studies will examine such changes as shifts in the location of disinfectant dosing, the use of alternative disinfectants, conversion from rapid sand filters to granular activated carbon, and use of biologically activated carbon and other methods to reduce undesirable treatment by-products. Field studies are planned to evaluate how water turbidity effects the efficiency of microbiologic disinfectants. Also to be studied are the physical, chemical, and microbial characteristics that permit the growth of microbes in water distribution systems with inadequate treatment practices, such as poor pipe corrosion control (C8, C12, C15)

Groundwater Contamination

For many areas of the country, the only groundwater data available is that which is generated when serious episodes of groundwater contamination occur. Such a general lack of baseline data precludes attempts to rank potential contamination sources, to evaluate their relative adverse impacts on human health, and, in many instances, to define feasible pollution prevention and control techniques. Our research program is designed to provide the methods for gathering this baseline information.

To assure the success of this data-gathering effort, it is important that we have the ability to accurately measure contaminants in groundwater. Thus, we will develop standard tests for determining rates at which contaminants move through the ground and changes in groundwater, particularly for industrial wastes containing significant amounts of organic solvents. We will also emphasize tests to determine the gross biological activity in saturated and unsaturated soils and will describe methods for the effective use of tracers, such as radioisotopes, to investigate groundwater. (D1, D5, D7)

Methods of characterizing the earth's subsurface will receive special emphasis, particularly because in selecting sites for underground waste storage and disposal facilities, knowledge of the vulnerability of underlying aquifers is vital to the maintenance of groundwater quality. We will evaluate surface resistivity techniques for use in locating contaminated areas in the subsurface environment. Natural microbiological populations in groundwater under varying hydrogeological situations will also be studied, and the presence of aerobic and anaerobic species and cyclic population densities will be examined. Our projects are designed to determine those parameters important in contaminant transport and how they vary within soil and aquifer systems. Finally, we will conduct trace elements analyses to correlate the background quality of the aquifer with aquifer type and age. (D2, D9)

We will study priority organic pollutants in a soil profile.

Knowledge of the transport and fate of contaminants in groundwater is needed to determine the degree of protection necessary to maintain water quality. A great deal of information on the movement of metals and inorganic chemicals in the saturated and unsaturated zones of the earth's subsurface has already been generated by the U.S. Geologic Survey. Organic chemicals, too, have been implicated in a number of groundwater contamination incidents and microbiological contaminants have been discovered in many rural wells.

Our transport and fate studies will concentrate on the transport and transformation of specific organics and viruses. (D4, D8) We will study priority organic pollutants in a soil profile to evaluate the probable groundwater impacts in the event that such compounds are released into the soil. The results of this research will be particularly important in predicting the consequences of chlorinating wastewater prior to land application and using such products as septic tank cleaners.

We also plan to examine the transport and fate of a selected group of organic compounds in simulated high-rate land application wastewater treatment systems. Models to describe the behavior of these pollutants will be developed, tested, and refined. (D8)

Reclaiming polluted groundwater is a relatively expensive long-term process.

Finally, the persistence of many consent decree compounds in aquifers will be studied. Included in the study waterill be phenols, phthalates, volatile chlorinated hydrocarbons, chlorinated benzenes, and aromatic ethers.

When conflicts arise about potential aquifer use, data must exist to facilitate informed decision making. Information on the impacts of specific sources of groundwater contamination and the economic benefits gained from not polluting must be weighed against groundwater degradation. (D11) To provide the information necessary, our research effort will first seek to understand the transport and fate of pollutants, then characterize subsurface environments, and finally concentrate on the specific pollution sources. This work will supplement studies on the background quality of groundwater in 34 states, studies that have so far identified 19 discrete sources of groundwater contamination ranging from septic tanks and cesspools to air pollution. (D12) The new research will provide information about several other contamination sources, among them improper water well construction and the costs involved to eliminate contamination. Techniques to rehabilitate wells at a reasonable cost will be evaluated.

Other planned research projects will concentrate on a variety of other areas:

- methods to calculate the radius of areas influenced by injection wells
- development of models to describe phenomena associated with groundwater recharge, i.e., where waste from advanced treatment facilities is injected into groundwater, either to reduce the intrusion of saltwater or to provide water for eventual reuse (D6)
- studies to promote groundwater protection through better construction, operation, and maintenance of septic tanks (in cooperation with the wastewater program—see chapter 6)
- studies into the extent and type of organics and viruses moving into soils and groundwater from high-rate land application systems (D3, D10)

Reclaiming polluted groundwater is a relatively expensive, long-term process, a process traditionally not undertaken because less expensive water sources have been available. However, as incidents of aquifer pollution proliferate, and as the number of water-short areas in the nation increases, the reclamation of groundwater becomes an attractive alternative. EPA plans to develop a groundwater reclamation research program that will use as its partial base results from our transport and transformation studies and groundwater methods development research. (D10)

The persistence of many consent decree compounds in aquifers will be studied.

DRINKING WATER RESEARCH PLAN—ORGANICS

PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
Health Effects	Concentrate and chemically characterize organics compounds from 5 cities water. **A1**	Select and evaluate indices of health significant organics. **A5**	Determine association between cancer and exposure to drinking water contaminants. **A9**	Select organic parameters which can be used for standards setting. **A15**	Toxicological and epidemiological validation of health significance of organic parameters. **A18**
		Health effects results on relation of chlorination to cancer. **A6**	Compare toxicity of organic reaction products and disinfectant concentrates. **A10**		Apply short-term bioassay in a national drinking water survey. **A19**
			Epidemiological study of health effects of chlorine dioxide. **A11**		
			Evaluate health effects of various treatment methods. **A12**		
Treatment Methods	Publish interim treatment guide for organic treatment processes. **A2**	Report on regeneration of granular activated carbon at field scale. **A7**	Analysis of field scale evaluation of organics control methods. **A13**	Report on control methods to avoid forming or control disinfection byproducts. **A16**	Evaluate and analyze economics of treatment method to meet organic maximum contaminants levels. **A20**
Analytical Methods	Quality assurance program to support monitoring requirements of Safe Drinking Water Act - evaluation samples, performance evaluations etc. **A3**	⟶	Annual Evaluations ⟶	⟶	⟶
	Publish protocol for broad-spectrum analysis of volatile organics. **A4**	Systems analysis to determine feasibility of major comprehensive monitoring program to determine distribution of trace organics. **A8**	Evaluate methods for identification and measurement of nonvolatile trace organics. **A14**	Establish computer library of all organic compounds found in water. **A17**	Develop improved analytical methods for organics of health significance. **A21**

DRINKING WATER RESEARCH PLAN—INORGANICS (incuding Asbestos)

PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
Health Effects	Epidemiological studies to evaluate current arsenic drinking water standard. **B1** Determine if methemoglobinema occurs in high nitrate areas. **B2** Identify inorganics in water treatment effluents. **B3** Symposium on drinking water quality and cardiovascular disease. **B4**	Report on epidemiology of dental flourosis. **B8** Report on occurrence of radionuclides and radon in drinking water. **B9** Determine effects of by-products of corrosive water. **B10** Report on health effects of barium. **B11**	Determine relationship between asbestos and cancer. **B15** Determine toxicity of inorganics in advanced waste treatment effluents. **B16** Determine effects of lead on susceptible populations. **B17** Report on relative body burden contribution of drinking water contaminants. **B18** Effects of inorganics on cardiovascular disease in two animal models. **B19**	Reports of relationship of nitrates to health. **B22** Assess health effects of additives. **B23**	Determine species of inorganic contaminants in drinking water and toxicity related to speciation. **B28**
Treatment Methods	Report on bench scale studies for control of inorganics. **B5**	Interim report on adapting treatment methods for use by small systems. **B16**	Report on use of package water treatment plants in small communities. **B20**	Evaluate cost of processes to meet revised regulations. **B24**	Evaluate disposal methods for wastes from water treatment plants. **B29**
Treatment Methods	Evaluate removal of inorganics by nonconventional treatment processes. **B6**	Evaluate treatment methods for prevention of corrosion. **B13**		Report on field evaluations of treatment methods for small systems. **B25** Evaluate ion exchange regeneration. **B26**	

PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
Analytical Methods	Quality assurance programs to support monitoring requirements of Safe Drinking Water Act - evaluation samples, performance evaluations, etc. Reference techniques for measuring asbestos. **B7**	Annual report →			
	Rapid screening techniques for identifying asbestos. **B14**	Compare several methods of multi-element analysis. **B21**	Analytical methods for species of inorganics. **B27**	Develop real-time inorganics monitoring devices. **B30**	

DRINKING WATER RESEARCH PLAN—MICROBIOLOGY

PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
Health Effects	Annual review of waterborne disease outbreaks. **C1**		Annual Report →		
	Determine minimum oral infectious dose of selected enteric viruses. **C2**	Determine significance of Giardia in water supplies. **C7**	Determine effect of changes in water treatment on low-level viral transmission. **C11**	Report surveillance of waterborne disease at the local level. **C13**	
Treatment Methods	Report on effect of home water treatment devices on bacterial levels and endotoxic occurrence. **C3** Determine microbiological implications of alternative treatment methods including alternative disinfectants. **C4**	Evaluate effects of turbidity on bacterial survival. **C8** Report on Giardia cyst and ova removal by filtration. **C9**	State of knowledge on growth of microorganisms in water distribution systems. **C12**	Evaluate effects of alternate treatment methods on bacterial levels. **C14**	State of knowledge report on microbial control in drinking water treatment and distribution systems. **C15**

DRINKING WATER RESEARCH PLAN—MICROBIOLOGY

PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
Analytical Methods	Quality assurance program to support monitoring requirements of Safe Drinking Water Act-evaluation samples, performance evaluations, etc. **C5**	→	Annual Report	→	→
	Establish transit time for microbiological samples **C6**	Improve methods for detecting viruses in water supplies **C10**			

DRINKING WATER RESEARCH PLAN—GROUNDWATER

PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
Ground Water	Methods for detecting contamination in the subsurface environment using selected biochemical indicators. **D1**	Define use of chemical and radioisotope tracers in ground-water investigations. **D5**	Methods for detecting plumes of contamination under waste sources, spills and leaks. **D7**	Report on reclamation of contaminated aquifers. **D10**	Protocols for determining pollution potential of activities in a specific geographical area. **D12**
	Manual of groundwater sampling practices. **D2**	Report on groundwater recharge. **D6**	Report describing the transport and transformation characteristics of selected toxic organics and viruses in high-rate and irrigation land treatment projects. **D8**	Evaluate the cost of degrading groundwater quality. **D11**	
	Report on radius of influence of injection wells. **D3**				
	Report on movement of organics in the subsurface environment. **D4**		Describe the natural geochemistry of groundwater. **D9**		

SOLID AND HAZARDOUS WASTES

Proper hazardous waste management eliminates the public health threat. EPA research emphasizes hazardous waste identification, treatment and containment.

The recent discovery of a number of dangerous situations that resulted from past hazardous wastes site mismanagement has made the establishment of a comprehensive national program to ensure the proper future management of hazardous wastes a major EPA priority.

EPA estimates that between 30 and 40 million tons of hazardous wastes are generated annually in the United States by 17 major types of industries. This amounts to between 300 to 400 pounds of hazardous wastes per capita each year requiring special handling. Distinguishing the wastes that require this special handling from among the 4 billion tons of solid waste each year that come from American homes, factories, farms, mines, and other sources makes the hazardous wastes management process a difficult one. As many as 3 billion of those 4 billion tons are mining and agricultural wastes which, though they must be handled properly, do not pose an immediate threat to public health and safety. A major focus of EPA's research effort has become the development of criteria to distinguish those wastes that are hazardous from those that are not.

EPA employs a stepped approach to solid wastes management:

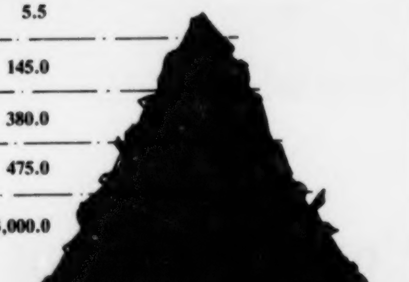
1. Reducing the generation of waste at the source by improving production processes, increasing durability and product life, and other techniques.
2. Removing both materials and energy from the waste stream to maximize recycling and resource recovery.
3. Ensuring that those wastes that cannot be eliminated or recovered are stored, transported, treated, and disposed of by procedures that guarantee public health and safety and the integrity of the environment.

The first two elements of this strategy are key goals in EPA's long-range solid wastes management program and research effort. The immediate threats posed by improper solid wastes disposal, especially of hazardous wastes, have made the third element the major short-range priority.

The EPA stepped approach to solid wastes management, with its short- and long-range priorities, was developed in response to Congress's passage of the 1976 Resource Conservation and Recovery Act (RCRA,

NATIONAL ANNUAL SOLID WASTE GENERATION

SOURCE	MILLIONS OF TONS
SEWAGE SLUDGE	5.5
MUNICIPAL AND COMMERCIAL	145.0
INDUSTRY	380.0
AGRICULTURE	475.0
MINING	3,000.0
TOTAL	4,005.5
AMOUNT HAZARDOUS	30-40*



*Hazardous wastes are found in all five sources for solid waste generation.

P.L. 94-580). In RCRA, Congress recognized the gravity of the hazardous wastes disposal situation and called for direct EPA action to remedy it. The Act mandated a stringent "cradle to grave" monitoring program to record and regulate the handling of hazardous wastes from generation to disposal. Those elements of RCRA dealing with non-hazardous wastes were also written to assure public health and safety. Of note, the Act requires the compilation of an inventory of those facilities not meeting minimum EPA guidelines for the siting and operation of solid wastes disposal facilities. Congress also clearly established resource conservation and recovery as a major priority in the solid wastes management effort.

Congress also clearly established resource conservation and recovery as a major priority.

EPA's research reflects RCRA's overall solid wastes management strategy, and the program will support RCRA's implementation. It also assures that the law can be strictly enforced and rationally applied under the broad variety of circumstances presented by our nation's complex economy and environment. The products of our research efforts are intended for use by industry, other federal agencies and state and local governments. In EPA's effort, attention has been focused on a number of research priorities. These include:

- Identification, assessment, quality assurance, and the technical assistance in support of EPA's efforts to promulgate and enforce hazardous wastes regulations under RCRA; this will be done while developing a strategy to manage the handling of uncontrolled sites as they are discovered; special attention will be paid to the development of a technical information base that can be used directly by individuals responsible for writing permits for hazardous waste treatment, storage and disposal;
- Development and testing of technologies to treat and contain hazardous wastes in order to minimize or eliminate their hazards;
- Assessment of the risks associated with hazardous wastes and the monitoring of the transport and fate;
- Development of a balanced program to manage non-hazardous wastes and high-volume wastes (those that are generated in large quantities and that may require special disposal research and development); this will be done while addressing the complex energy and resource use allocations associated with solid and hazardous wastes.

The establishment of research priorities has been closely coordinated with the Office of Solid Waste and its RCRA responsibilities. Those research areas that have been designated "short-term" high-priority areas that are ongoing or scheduled to start in early FY 80. In most cases the data produced by this short-term research are directly required by RCRA or are in support of RCRA standards and guidelines. Adequate funding is expected in these areas.

Establishment of research priorities has been closely coordinated with the Office of Solid Waste.

"Medium-term" research refers to data to be produced by FY 83 or 84. Some of this longer-term work is already underway to meet medium RCRA needs while other projects will be started in out years. Out-year funding is anticipated for these medium-term projects.

"Long-term" research refers to outputs to

SHORT, MEDIUM, AND LONG-TERM RESEARCH NEEDS IN RESPONSE TO THE RESOURCE CONSERVATION AND RECOVERY ACT (RCRA)

Research Categories	Hazardous Waste Identification				Hazardous Waste Technology			Hazardous Waste Effects		High Volume Wastes		Non-Hazardous Wastes	
Research Areas / RCRA Programs	Quality Assurance	Waste Characterization	Abandoned Facilities Response	Pollution Migration and Retention in Soils	Treatment	Thermal Decomposition	Containment	Health Effects	Transport and Fate	Mining	Electric Utility and Fuel Processing	Municipal Solid Wastes	Waste-as-a-Fuel
Section 1008: Guidelines	***	***	***	*	**	**	**	*	*	*	*	**	*
Section 2003: Resource Recovery and Conservation Panels	NA	NA	NA	NA	*	NA	NA	NA	NA	NA	NA	**	**
Section 3001: Identification and Listing of Hazardous Waste	***	***	NA	NA	NA	NA	NA	*	NA	**	**	NA	NA
Section 3002: Standards Applicable to Generators of Hazardous Wastes	***	***	NA[1]	*	***	***	***	*	*	*	*	NA	NA
Section 3003: Standards Applicable to Transporters of Hazardous Wastes	NA	***	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Section 3004: Standards Applicable to Owners & Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities.	***	***	NA[1]	*	***	***	***	*	*	*	*	NA	NA
Section 3005: Permits for Treatment, Storage, or Disposal of Hazardous Wastes.	***	***	NA[1]	*	***	***	***	*	*	*	*	NA	NA
Section 3007: Inspections	***	***	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Section 3008: Federal Enforcement	***	***	***	**	***	***	***	**	**	NA	NA	NA	NA
Section 3010: Effective Date	***	***	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Section 4002: Federal Guidelines for Plans	NA	**	NA	NA	NA	NA	NA	NA	NA	NA	NA	**	*
Section 4004: Criteria for Sanitary Landfills	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	***	NA
Section 4005: Upgrading of Open Dumps	NA	NA	**	*	NA	NA	NA	*	**	NA[2]	NA[2]	**	NA
Section 7003: Imminent Hazard	NA	***	***	**	**	*	*	*	**	NA	NA	NA	NA
Section 7007: Grants or Contracts for Training Projects	*	*	*	*	*	*	*	*	*	*	*	*	*
Section 8001: Research Demonstrations, Training and Other Activities	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Section 8002: Special Studies	NA	NA	NA	NA	NA	NA	NA	NA	NA	**	NA	***	NA
Section 8003: Coordination, Collection, & Dissemination of Information	NA	***	***	*	**	**	**	*	*	*	*	*	*
Section 8004: Full-Scale Demonstration Facilities	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Section 8005: Special Study & Demonstration Projects on Recovery of Useful Energy & Materials	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	*	*
Section 8006: Grants for Resource Recovery Systems and Improved Solid Waste Disposal Facilities	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	*	*

Note: All research products are intended for use by federal, state and local governments.
Also Note: All research, development, and demonstration pertaining to hazardous wastes will take place at federal facilities or on federal lands.

LEGEND:

1. Short term need if generator is responsible or proven responsible for abandoned site.
2. Unless open dump is associated with a mine.

NA Not Applicable

* Long Term
** Medium Term
*** Short Term

be produced in FY 85 and beyond. This category contains a number of lower-priority projects that will be started in out-years if funds are available.

All of our research pertaining to hazardous waste will be conducted on federally owned lands or in federal facilities.

Hazardous Waste Identification

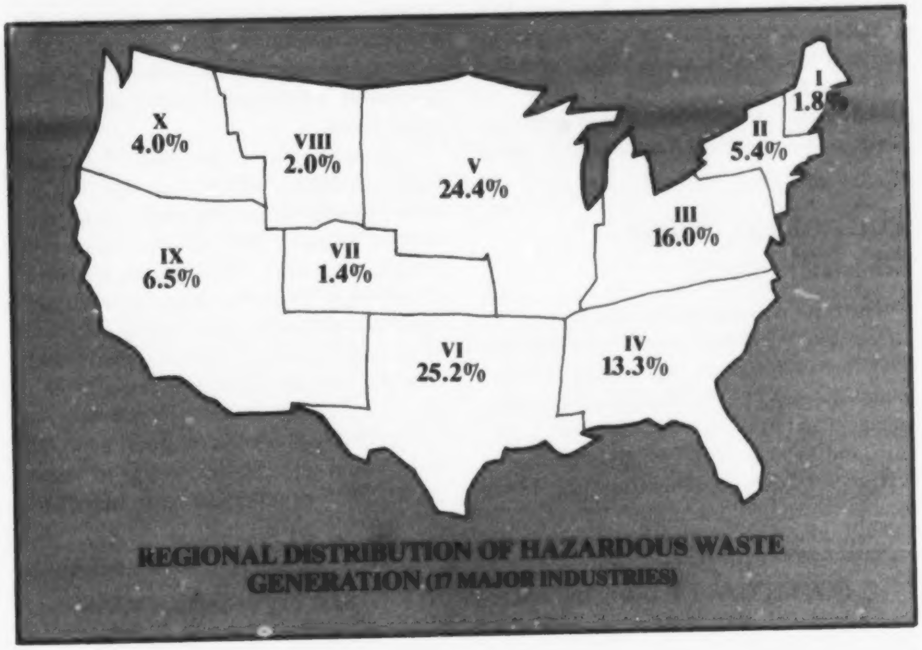
The fact that only 30 to 40 million tons out of the more than 4 billion tons of solid wastes generated annually is hazardous severely complicates proper hazardous wastes management and treatment. Segregation is difficult and even further complicated by the variety of sources generating hazardous wastes—sources that are all on the rise and estimated to continue growing at a rate of 3 percent each year. By the year 2000, annual hazardous wastes generation could top 75 million tons.

Hazardous wastes are emitted from or found in pipes, ponds, lagoons, settling tanks, and countless other media at countless sites nationwide. They can be solid, liquid, sludge, or gaseous. RCA defines a waste as hazardous if "because of its quantity, concentration or physical, chemical or infectious characteristics it: (a) causes or significantly contributes to an increase in mortality or an increase in serious irreversible or incapacitating reversible illness; or (b) poses a substantial present or potential hazard to human health or the environment when improperly

POTENTIALLY HAZARDOUS WASTE GROWTH PROJECTIONS

INDUSTRY	AMOUNT (Million Metric Tons/Year)						% Growth* '74-'83
	1974		1977		1983		
	DRY	WET	DRY	WET	DRY	WET	
1 Batteries	0.005	0.010	0.082	0.164	0.105	0.209	2000
2 Inorganic Chemicals	2.000	3.400	2.300	3.900	2.800	4.800	40
3 Organic Chemical, Pesticides, and Explosives	2.150	6.860	3.500	11.666	3.800	12.666	77
4 Electroplating	0.909	5.276	1.316	4.053	1.751	5.260	92
5 Paint and Allied Products	0.075	0.096	0.084	0.110	0.105	0.145	40
6 Petroleum Refining	0.625	1.757	0.715	1.841	0.811	1.888	30
7 Pharmaceuticals	0.062	0.065	0.070	0.074	0.104	0.108	68
8 Primary Metals Smelting and Refining	4.454	8.335	4.732	9.104	5.536	10.418	24
9 Textile Dyeing and Finishing	0.048	1.770	0.500	1.870	0.179	0.716	373
10 Leather Tanning	0.045	0.146	0.050	0.143	0.068	0.214	51
11 Special Machinery	0.102	0.163	0.094	0.153	0.157	0.209	54
12 Electronic Components	0.026	0.036	0.036	0.078	0.050	0.108	92
13 Rubber and Plastics	0.205	0.785	0.242	0.944	0.299	1.204	46
14 Waste Oil Re-Refining	0.057	0.057	0.074	0.074	0.144	0.144	253

*Figures based on dry weight quantities.



REGIONAL DISTRIBUTION OF HAZARDOUS WASTE GENERATION (17 MAJOR INDUSTRIES)

treated, stored, transported, or disposed of or otherwise managed." The wide assortment of sources, sites, forms, and characteristics makes proper identification, hazard assessment, and quality control a difficult task for EPA, one requiring accurate testing methods and procedures. The top priority of the research program is the development of such testing tools.

Four major research areas provide support for the promulgation of EPA regulations under RCRA. These areas are:

- Measurement—Better analytical data is essential if EPA is to make more informed decisions. Obtaining this data will require standard methods and protocols for analyzing hazardous wastes. The research must first examine existing methods and protocols, then, if needed, new methods and procedures must be developed and tested to fill any gaps. Accuracy, reproducibility and precision are of the utmost importance to support RCRA enforcement. (A1, A2, A7, A11, A14)
- Monitoring—With improved procedures and protocols in place, EPA will be able to better fulfill its responsibilities under RCRA to monitor hazardous wastes generation, storage, transport, treatment, and disposal. However, such a monitoring effort requires a systematic approach, and guidelines for such an approach currently do not exist. The development of monitoring guidelines has been given a high priority, and when established must specify methods, procedures and protocols. (A10) Site selection guidelines will be needed for states and localities to determine hazardous wastes disposal site suitability and to establish whether or not existing sites pose hazards to public health and safety. (A10)
- Quality assurance—In order to guarantee the reliability of both the measurement and monitoring programs and to defend them against legal challenges, a quality assurance program is required. Research will assist in the program's establishment by providing standard reference materials, developing minimum laboratory standards and practices, establishing a laboratory evaluation program, initiating a laboratory intercomparison program, and devising a procedure to evaluate equivalent methods. (A3, A4, A5, A6, A8, A9, A12)

- Technical assistance—The complexity of the problems presented by hazardous wastes challenges both EPA headquarters and regional program staffs. The research program responds to that challenge by providing support in such areas as remote sensing (through aerial photography, for example), complex sample analysis, and quick-response methods for analyses that regional laboratories do not have the facilities or standard methods to perform. (A13)

The quality assurance program will be a major research priority during the next five years, and while development of such a program for hazardous wastes is a highly complex task, the program should be fully operational within the five-year period. A major effort will also be geared toward the characterization of specific hazardous wastes streams.

All of our research pertaining to hazardous wastes will be conducted on federally owned lands or in federal facilities.

The past mismanagment of hazardous wastes sites has produced serious threats to human health and the environment in every region of the country. The consequent need for remedial action has revealed how little is actually known about the potential consequences of improper waste handling, or how to deal with those consequences when they arise. No single case has focused more attention on the hazardous wastes site issue than the discoveries made in the Love Canal area of Niagara Falls, New York. Here a former chemical dump site, around which later developed a residential neighborhood, was linked to human liver and kidney ailments as well as to other chronic biological impacts, including miscarriages and birth defects. In addition, long-term repercussions resulting from exposure to known and suspected cancer-causing agents is anticipated.

EPA has evaluated other dump sites for the feasibility of remedial action. A first concern in these and other such cases is to prevent pollution from migrating from the site to the surrounding environment. But to quantify fully the impacts that these incidents have had, or will have, on the environment and upon the people living nearby, requires further extensive research.

The EPA estimates that thousands of sites where wastes have been improperly dumped still remain to be discovered. The Agency also recognizes that the potential effects from site wastes will differ dramatically from site to site. Certainly, not all such incidents will be of the proportion of Love Canal. On the contrary, it is expected that most of the sites yet to be discovered will be small.

A key short-range EPA research product will be the development of a protocol to be used by state and local governments for quantitatively determining the degree of hazard posed by an uncontrolled site. The protocol will address such considerations as potential movement to the surrounding environment (B3), potential for public exposure, nature of the pollutant materials on the site, and potential consequences of waste reactivation. Field evaluations will be conducted at actual dump sites on federal lands to test the effectiveness, durability, cost, and technical feasibility of remedial clean-up schemes that provide permanent uncontrolled site containment. Also evaluated on federal lands or in federal facilities will be technologies for the on-site treatment or destruction of hazardous wastes, leachates, and contaminated groundwater. (B2, B3, B4, B5, B6)

A guidance manual will be published along with unit technology design and operations manuals outlining specific quick-response treatments and containment technologies for states and localities to deal with uncontrolled waste site situations. (B7, B8) Improved methods for decontaminating soils in the vicinity of polluted sites and improved, multipurpose mobile clean-up equipment will also be developed. (B1, B9, B10, B11)

Innovative Management Technologies

Next to an enforceable regulatory program, the most important step in guaranteeing public protection from the effects of hazardous wastes involves the development of the best possible wastes handling technologies and procedures. The complex individual nature of each waste complicates such an effort, however, since virtually every waste has its own unique storage, treatment, and disposal requirements. While several adequate disposal facilities exist, many are below RCRA standards, and when the quantities of hazardous wastes requiring handling increase because of RCRA, the capacities of these facilities will be severely taxed.

At present, 70 to 80 percent of all hazardous wastes from the key producing industries is disposed of at the site where it is generated. It is estimated that today only 10 percent of all hazardous wastes is managed in accordance with the standards proposed by EPA under RCRA. Another 10 percent is incinerated without proper controls and fully 80 percent is disposed of in sorely inadequate landfills, lagoons, or ponds.

RESEARCH EFFORTS ON REMEDIAL ACTION AT UNCONTROLLED WASTE SITES

LOCATION	TYPES OF WASTES INVOLVED	AREA POLLUTED	RESEARCH ARRANGEMENT	REMEDIAL ACTIONS RECOMMENDED
Li Pari Landfill, Gloucester Co., NJ	Hazardous Organics	Alcyon Lake	Contractual	Too Early
La Bounty Landfill, Charles City, IO	Arsenic-laden pharmaceutical sludges	Cedar River	Contractual	Regrading of surface with 2 ft. of clay cap (may add grout curtain or bottom seal)
Municipal Landfill, Windham, CT	Municipal wastes	Local drinking water reservoir	Contractual	Surface capping with clay
Candy Box Farm Landfill, Coventry, RI	Chemical wastes including sodium aluminum hydride	Nearby cranberry bog and swamp	Contractual	Too Early
Kin-Buc Landfill Edison, NJ	Assorted chemical wastes	Air and groundwater in area	Technical assistance	Containment strategies
Love Canal Niagra Falls, NY	Barrels, drums and bulk chemical wastes	Basements of homes; yards in residential neighborhood	Technical assistance to New York Department of Environmental Conservation	Various strategies for containment of remaining ⅔ of site not covered in emergency clean-up

Note: All research, development and demonstration pertaining to hazardous wastes will take place at federal facilities or on federal lands.

TECHNOLOGICAL RESEARCH NEEDS FOR UNCONTROLLED HAZARDOUS SITES CONTROL PROGRAM

PROBLEM	RESEARCH FOCUS
SURFACE WATER CONTROL	Contour grading, diversion, surface sealing, revegetation, etc.
GROUNDWATER CONTROL	Bentonite Clay-Slurry Trench, cutoff walls, grout curtains, sheetpiling cutoff walls, bottom sealing, etc.
CHEMICAL IMMOBILIZATION	Chemical fixation, injection
PLUME MANAGEMENT	Groundwater/leachate extraction, injection techniques, leachate/polluted groundwater collection and treatment
ON-SITE TREATMENT/ DESTRUCTION	Mobile spill clean-up equipment, modified multiple-stage thin film distillation, lagooning (dewatering, fixation, treatment stabilization), modular biological treatment methods (chemical stabilization, nutrient injection and microbe injection), and on-site bulk waste encapsulation

Note: All research, development, and demonstration pertaining to hazardous wastes will take place at federal facilities or on federal land.

There are four basic categories of hazardous wastes management technology. These are recycling/reuse, treatment, thermal decomposition (incineration), and containment (disposal). Required present and future incineration and disposal facility capacities for the 17 major industries that generate hazardous wastes have already been established. But similar projections for treatment processes are yet to be made. The costs of developing such facilities as required under RCRA poses a potential economic hardship for some hazardous wastes generators and this subsequently points to the need for the development of new and innovative hazardous wastes facilities and control technologies.

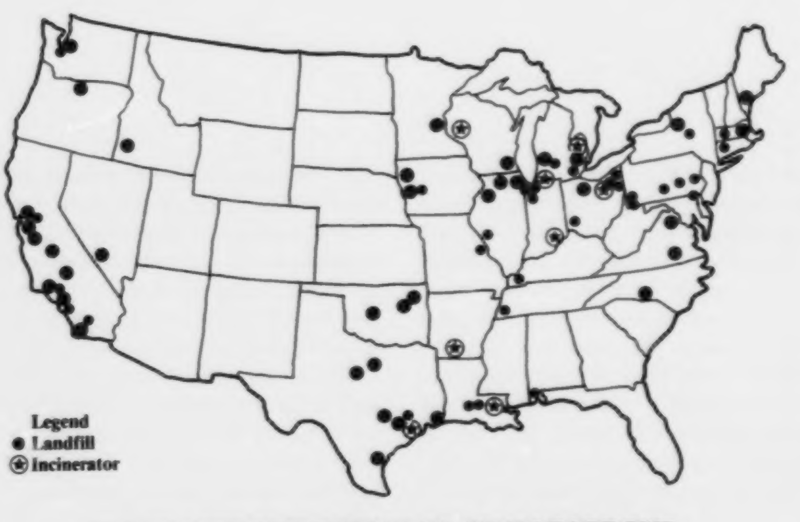
RCRA enforcement will place significantly increased demands on the already strained hazardous wastes management industry. In response to the increased demands, EPA's hazardous wastes technology research objective is to develop and make available the technological information necessary to upgrade existing hazardous wastes facilities as well as for the installation of new facilities. EPA realizes that it is not feasible to study each hazardous waste stream and every potential technology. A good deal of the research effort is being assumed by the waste generators themselves as a result of the economic incentives provided under RCRA.

EPA's hazardous wastes technology research program is concerned with the following types of waste:

1. Highly hazardous wastes (for example, those containing highly toxic or bioaccumulative compounds such as PCB, TCDD, cadmium, beryllium, etc.).
2. Wastes from industry groups composed primarily of relatively small companies such as those that work with specialty chemicals, wood preservatives, or leather tanning or secondary nonferrous industries, companies that would likely be unable to conduct effective research and development on their own.
3. Wastes from industry groups most likely to suffer the greatest economic impact from RCRA enforcement (for example, metal finishing and electroplating).
4. Wastes that would most likely be best managed off-site, in centralized public or private facilities.

Top-priority EPA technology research needs include the continued development, validation, and testing of incineration systems for reliability (D1); the ongoing testing of various technologies to neutralize, detoxify, and destroy hazardous wastes (C3); and the assessment of volatilization problems of hazardous wastes placed into surface impoundments (E3). The work will take place in federal installations or on federal lands.

Among the efforts to be undertaken by EPA's hazardous wastes management technology research will be less than full-scale performance tests of promising control technologies for priority hazardous wastes streams. (C7) Research will also focus on the possibility of adapting existing nonhazardous treatment technologies for use with hazardous wastes. Additionally, thermal combustion and containment technologies as well as industrial process technologies will be studied for their potential application to priority hazardous wastes streams. (C2) Profiles will be developed and published to



GEOGRAPHIC DISTRIBUTION OF HAZARDOUS WASTE MANAGEMENT FACILITIES

CURRENT AND PROJECTED HAZARDOUS WASTE DISPOSAL TECHNOLOGIES (millions of metric tons)

		1977	Projected	1977	Projected	1977	Projected
INDUSTRY	Annual Waste Generation	Landfill	Secure Landfill	Incineration	Incineration	Other* Techniques	Other** Techniques
1 ELECTRONIC COMPONENTS	.064	—	.039	—	.025	—	—
2 ELECTROPLATING & METAL FINISHING	.64	.064	.64	—	—	—	—
3 INORGANIC CHEMICALS	3.8	1.3	3.8	—	—	2.5	—
4 LEATHER TANNING & FINISHING	.17	.17	.17	—	—	—	—
5 METALS SMELTING & REFINING	12.8	8.4	7.8	—	—	4.4	5.0
6 ORGANIC CHEMICALS (Segments Analyzed)	.34	.214	.056	.03	.284	.07	—
7 PAINTS & ALLIED PRODUCTS	.22	.11	.12	.11	.10	—	—
8 PETROLEUM REFINING	1.5	1.3	1.2	—	—	.2	.3
9 PETROLEUM RE-REFINING	.074	.074	.074	—	—	—	—
10 PHARMACEUTICALS	.073	.008	.008	.065	.065	—	—
11 RUBBER	.050	.05	.050	—	—	—	—
12 PLASTICS	.900	—	—	.90	.900	—	—
13 SPECIAL MACHINERY	.075	.075	.064	—	.011	—	—
14 STORAGE & PRIMARY BATTERIES	.15	.15	.15	—	—	—	—
15 TEXTILES	1.7	1.7	1.7	—	—	—	—
16 EXPLOSIVES	.09	—	—	.09	.09	—	—
17 PESTICIDES	.7	.902	.03	.008	—	.68	—
TOTAL	23.3	14.3	15.9	1.2	1.9	7.8	6.0

* Other techniques for 1977 include lagoon, landspreading, deep-well injection, and sea disposal.

** Projected techniques include landspeading, lagoon, and deep-well.

Source: Draft Economic Impact Analysis (Regulatory Analysis Supplement) for Subtitle C, Resource Conservation and Recovery Act of 1976. Prepared by Office of Solid Waste, USEPA, January 1979, pp. 180 and 181.

outline performance characteristics of tested technologies in specific hazardous wastes streams. Included will be preferred modes of operation, operational difficulties incurred, capital and operating costs, energy requirements, and estimates of the technology's compatibility with other waste streams. (C5)

Efforts will also be made to develop and verify quick-indicator procedures capable of predicting the compatibility of a given control technology with a specific waste stream. Engineering design, operation, and safety requirements for hazardous wastes control technology unit operations and processes will be developed and disseminated along with user-oriented protocols for hazardous wastes technology problem assessment, technology selection, and control system design. (C4) Evaluations will also be made of novel hazardous wastes control technologies that offer prospects for improved performance, safety, energy efficiency, cost effectiveness or unique applicability to problem waste streams. (C7)

Examples of short-range research projects in each technology area include the following:

- Treatment—Development and less than full-scale testing of bio-degradation processes and technologies capable of concentrating a number of priority hazardous wastes streams, thus allowing for their centralized treatment, (C1)
- Thermal Decomposition (incineration) —Conducting laboratory-scale thermal decomposition studies of selected pure compound and hazardous wastes streams to identify required destruction conditions and the potentially hazardous

PROJECTED GROWTH OF THE HAZARDOUS WASTE MANAGEMENT INDUSTRY, 1983

ITEM	GROWTH BASED ON HISTORIC TRENDS	GROWTH BASED ON APPLICATION OF NEW DISPOSAL REGULATIONS
U.S. Demand[1] (million wet metric tons/yr)[2]	4.5	8.9
Number of Companies	75 to 85	90 to 100
Number of Facilities	130 to 140	160 to 170
Capacity Required to Meet Demand on an EPA Regional Basis (million wet metric tons per year)	5	11.0 (12 with 10% excess)
Forecasted Capacity by EPA Regional Basis (million wet metric tons per year)	8.3	9.1
Revenues (1980 dollars in millions)	$210 to $225	$460 to $490
Employment (number)	2,100	4,500
Tangible Assets (dollars in millions)	$210	$560 to $700

[1] Quantity of wastes available for treatment and disposal.

[2] Includes water weight.

by-products of the thermal decomposition process. (D2, D3, D4, D5, D6, D7)

- Containment (disposal) — Development and verification on federal land of a protocol for predicting the composition, rate of generation, and total quantity of leachates from hazardous waste land disposal facilities and the development of a quick-indicator test for predicting the growth and movement of leachates and leachate contaminants from land disposal facilities. (E1, E2, E4, E5, E6, E7, E8, E9, E10)

Tracking Pollutants and Their Health Effects

Both hazardous and non-hazardous wastes disposed of on land generate gases and liquids (called leachates) as by-products of waste decomposition. Predicting the movement of these gases and leachates within the disposal facility has been a long-standing problem faced by facility managers. Monitoring the transport and fate of both substances is also an important disposal concern, since both gases and leachates eventually escape from the facility into the surrounding environment. Because of this eventuality, an assessment of the effects that the gases and leachates might have on the health of persons exposed to them must also be made. This ultimate concern for public health and safety reflects the number one priority of RCRA and EPA's chief goal in its subsequent implementation.

To track the movement of pollutants at disposal sites, monitoring methods that allow the use of selected indicators to detect biochemical contamination in subsurface environments will be developed. (G1) Protocols will be developed for the use of chemical and isotope tracers in groundwater investigations. (G2) The use of thermoplastic casings to prevent deterioration of wellbores will be evaluated as will economical techniques for restoring wells that have failed. Methods for predicting leachates and gas migration from solid wastes landfills and from certain hazardous wastes sites will also be studied. The design of soil covers to minimize the release of vapors from disposal sites is but one example of the kind of research effort in the works. (G3, G4)

Developing methods to accurately predict the movement of toxicants and other wastes is also a priority. (G5, G6, G7, G8) These efforts are all a part of EPA's high-priority program to make land disposal of hazardous wastes as safe, as reliable, and as easy to control as technologically possible.

EPA needs to provide for technical support, chemical, biological, epidemiological, toxicological, and clinical tests where appropriate to determine the risks from hazardous waste sites. The effort will include primarily coordination of various work done by other agencies such as the National Cancer Institute, National Institute of Environmental Health Sciences, Center for Disease Control and National Center for Health Statistics.

Often in dealing with hazardous waste disposal sites, it is not possible to eliminate the hazardous materials from the environment, i.e., some hazardous substances, no matter what is done, will continue to show up in food, drinking water or the air. In such cases it is necessary to provide an estimate of the residual risk as a function of various control and abatement actions.

Research in the risk assessment area may include efforts to:

- Determine which measurements are needed to ascertain exposure and to calculate risk, i.e., air exposures, drinking water exposures, levels of substances in soils;
- Determine the critical population at risk and for which health effects;
- Extract from available data a dose-response relationship in the areas and routes of exposure of interest;
- Perform short-term tests where needed and useful;
- Provide from the above, an estimate of the number of persons affected for health effects of concern and an estimate of the increased individual risk for the most exposed group. (F1 through F7)

High-Volume Wastes

While hazardous wastes occupy the top priority in the ongoing research effort, they are not the only wastes that are difficult to manage or that pose a potential threat to public health and safety. In terms of quantity, the 3-billion tons of high-volume wastes from mining operations and other sources, for example, present serious management problems. While most of these wastes are inert, some are potentially hazardous, and have thus been classified along with other high-volume wastes by EPA. The designation indicates that these wastes will receive special research and development attention because of the extremely high rate at which they are generated and the potential environmental threat they may pose.

The high-volume wastes research effort is projected to concentrate primarily on determining potential dangers posed by such wastes and on setting control priorities. Some very large mining operations, such as for sand and gravel are already known to produce totally inert wastes; other mining operations, such as for coal that produce some hazardous wastes, have been studied extensively and will thus, require little additional work. Still other mining operations, however, such as mercury mining, result in potentially highly toxic wastes though they produce smaller volumes of waste. Other mines produce high-waste volumes, but their full hazard potential is still to be investigated. Such mines include uranium, phosphate, and metallic ore mines.

There are several high-volume wastes research efforts planned. Among them are:

- Cost assessments of RCRA impacts on various mining operations;
- Surveys of the best management practices in mines;
- Evaluations of the best practices for mining waste storage, treatment, and disposal;
- Preparation of a management practices guidance document for handling coal mining wastes. (I1, I2, I3, I4)

The high-volume waste research and development program also applies to coal ash and flue gas desulfurization (FGD) from all steam power plants. Full-scale field evaluations will be undertaken to determine which disposal methods will enable compliance with proposed RCRA performance standards and what the costs would be to the utility industry to bring all disposal sites to compliance levels. (J1, J2) In addition, EPA will assess the potential dangers posed by disposal and reuse of coal ash and FGD waste, and investigate damage cases relating to coal ash and FGD waste disposal. An example of such a potential danger is the emission of radioactive radon gas from coal ash used in building materials, from reclaimed coal ash storage sites, or from fugitive emissions during coal ash transportation. (J3, J4) Data that characterize and compare the wastes generated by industrial boilers and utility boilers will also be developed.

While most of these wastes are inert, some are potentially hazardous.

In the long-term, three combustion wastes — hog fuel ash, refuse-derived fuel ash (RDF), and oil field steam generation RGD waste (J5)—will be added to the high volume wastes research and development program. Other research will involve the potential waste streams associated with geothermal energy.

Non-Hazardous Wastes

Until RCRA came into existence in 1976, the major focus of EPA's research effort in solid wastes was on non-hazardous wastes, specifically municipal solid wastes. This emphasis grew out of the legislative mandates of the 1965 Solid Waste Disposal Act as amended by the Resource Recovery Act of 1970. While RCRA clearly set top priorities on hazardous wastes management, it also gave EPA the responsibility for managing municipal wastes as well.

Over 150 million tons of municipal wastes are generated annually. Sewage sludge accounts for an additional 5 million tons and construction/demolition debris adds another 45 million tons. This brings the total to over 200 million tons of wastes, a figure that is growing each year. There are an estimated 20,000 disposal facilities to manage these wastes around the country, but many are located in areas unsuited to waste disposal and/or are improperly operated.

Improper disposal has resulted in the contamination of surface and groundwaters, exposure of humans to toxic or pathogenic wastes, explosions of landfill gas, contamination of croplands with heavy metals, air pollution, and destruction of wetlands, critical habitats, and other sensitive areas. Groundwater contamination is particularly serious, since groundwater is the water source for half of the United States population and the rehabilitation of seriously contaminated groundwater is both costly and time consuming. It has been estimated that over half of all disposal facilities leak contaminants into groundwater supplies. (See chapter 7, "Drinking Water.")

There are an estimated 20,000 disposal facilities.

Solid wastes management is also expensive. It is, in fact, the second most costly municipal service — behind education, but ahead of police and fire protection and transit and other services. Under RCRA, an inventory of municipal wastes disposal facilities not meeting standards set by EPA for sanitary landfills is to be compiled. In addition, both RCRA and our national priorities give impetus to the continuation of many ongoing research efforts in municipal wastes resource conservation and recovery program.

Research to predict and track the release of contaminants from disposal operations involving hazardous wastes is also being applied to the release of contaminants in non-hazardous waste facilities. Other non-hazardous wastes research priorities include controlling the decomposition of wastes within municipal landfills and the migration of gas and leachates. Additionally, EPA is

SPECIAL WASTES

(Metric Ton / yr)

WASTE	QUANTITY	POSSIBLE HAZARD
Cement Kiln Dust	12 million*	Alkalinity and heavy metals
Utility Waste (fly ash, bottom ash, scrubber sludge)	66 million*	Heavy metals (trace
Phosphate Mining, Beneficiation, and Processing Waste	400 million	Radioactivity (low levels)
Uranium Mining	150 million	Radioactivity
Other Mining Wastes	3 billion*	Heavy metals, acidity
Gas and Oil Drilling Muds and Oil Production Brines	5 million*	Alkalinity, heavy metals, toxic organics, salinity

NOTE: It is not yet known how much of the total quantity of waste marked with an asterisk (*) is, in fact, hazardous waste.

attempting to develop a disposal facility environmental evaluation procedure, one that spells out cost-effective, environmentally sound methods for the disposal of non-hazardous wastes and remedial actions that should be taken to clean up non-hazardous wastes facilities. (L1 through L9)

Wastes-to-energy conversion methods are also a priority of the research program, with special attention being given to the monitoring and evaluation of systems developed during previous research efforts. Development of secondary materials specifications to facilitate recycling is also slated for attention. (K1 through K8)

Final Thoughts

EPA's solid and hazardous wastes research strategy is clearly designed to tackle the toughest wastes management problems. The protection of public health and safety is currently the primary program concern, and not until the RCRA-mandated hazardous wastes regulatory program is in place can EPA's concern lessen. However, development of safe, efficient, cost-effective methods for handling hazardous wastes is also being given a great deal of attention.

EPA is carefully monitoring and coordinating its solid and hazardous wastes research activities with other federal and non-federal study efforts in the same field. The research strategy reflects this interface as well as the needs and priorities pinpointed by EPA Regional Offices.

Only through a balanced and carefully gauged research effort can EPA provide the technical, scientific, and procedural information necessary to alleviate the nation's solid and hazardous waste management problems. Unless such an effort is vigorously pursued, repetition of the events associated with the Love Canal area will continue to occur. With the proper research, however, past mismanagement can be rectified, future harmful incidents can be prevented and public health and safety can be assured.

The protection of public health and safety is currently the primary program concern.

SOLID AND HAZARDOUS WASTE RESEARCH PLAN

PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
HAZARDOUS WASTE IDENTIFICATION **Quality Assurance (QA) Program** *This program is to develop the necessary protocols to sample, analyze, identify, and characterize hazardous wastes*	Provide new reference ''standard'' materials **A1**	Develop QA methods and materials for volatiles **A6**	Establish protocols for field monitoring of remedial actions **A10**	Develop innovative sampling and analytical procedures **A13**	Perform hazardous waste characterization for all other industries **A14**
	Perform laboratory intercomparison studies **A2**	Publish laboratory evaluation criteria, methods and procedures manual **A7**	Perform hazardous waste characterization for high priority industries **A11**		
	Establish QA program for uncontrolled site program **A3**	Perform a QA training program **A8**	Develop procedures for re-evaluating data in the repository **A12**		
	Adapt and validate existing sampling, extraction and analytical methods from other EPA programs to RCRA, Subtitle C regulations **A4**	Validate methods and extablish QA procedures for newly identified hazardous materials **A9**			
	Institute a repository and review system for tapes and data **A5**				

SOLID AND HAZARDOUS WASTE RESEARCH PLAN

PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
Uncontrolled Facilities Response *This area validates various surface and groundwater control schemes and chemical immobilization to contain pollutants emanating from waste disposal sites.*	Evaluate mobile incinerator **B1** Adapt existing technology for "quick fix" remedial measures for uncontrolled dump sites **B2**	Develop protocol for quantitatively determining the degree of hazard of an uncontrolled facility; produce engineering design guidance for leacnate collection systems for use by states and local governments **B3** Develop and field verify engineering design guidance for selection of cover materials for infiltration control and volatile control at land disposal facilities. **B4**	Evaluate the effectiveness, durability, cost, and technical feasibility of remedial action schemes for permanent containment of polluting sites **B5** Develop methods for locating and repairing landfill and surface impoundment liner failures. **B6**	Develop and publish a guidance manual for remedial action technology at polluting hazardous waste sites **B7** Develop a series of unit-technology design and implementation manuals for specific quick-response, treatment and containment technologies **B8** Develop improved methods for decontamination of soils in the vicinity of polluting sites **B9** Develop improved, multi-purpose mobile clean-up equipment and initiate efforts to encourage commercial construction and operation of proven units **B10**	Develop, construct and field demonstrate at federal sites, technology for on-site treatment/ destruction of hazardous waste, leachates, and contaminated groundwater, complete short term monitoring of demonstration site. **B11**
HAZARDOUS WASTE TECHNOLOGY					
Treatment *This technology is defined to include recycle, detoxification, and biological treatment of hazardous wastes.*	Develop and field-scale testing of biodegradation processes and technologies for concentrations of priorty RCRA hazardous waste streams **C1**	Evaluation of techniques for reducing hazardous wastes by industrial process changes and recycle of hazardous wate stream components **C2** Identification and testing of treatment technology operation requirements for partial de-toxification of high hazard wastes **C3**	Develop and disseminate standard performance testing protocols for hazardous waste treatment processes and systems tested by industry, waste management facility operators, EPA and states **C4** Develop technology profiles for performance, cost, waste stream compatibility and energy efficiency capabilities **C5**	Evaluate technologies and methods for upgrading safety, performance and capacity of existing hazardous waste treatment facilities **C6**	Piolt-scale testing and demonstrate novel emerging, high technology hazardous waste destruction methods **C7**

PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
Thermal Decomposition					
This technology is defined to include all types of incineration.	Conduct laboratory-scale thermal decomposition studies of selected pure compounds and hazardous waste streams to permit preliminary screening and identification of required destruction conditions and potentially hazardous decomposition products **D1**	Conduct field-scale test burns on specific waste streams to determine parametric conditions for complete destruction of classes of hazardous wastes in a commercially available hazardous waste incinerator to provide assistance to EPA regional permit writers and for a quick response basis **D2** Evaluate feasibility of using existing alternative combustion facilities for co-combustion of certain hazardous waste streams **D3**	Develop and verify means of transferring small-scale compustion test results to field-scale testing conditions and requirements. Develop a waste stream/ inceneration technology compactability protocol. **D4** Develop and validate standard sampling and on-line testing analysis procedures and equipment for monitoring full-scale test burns and for permit compliance monitoring **D5**	Develop advanced air pollution control technology for hazardous waste incineration. **D6** Evaluate and test techniques and incinerator design modifications to reduce energy requirements in hazardous waste incineration	Conduct pilot-scale studies of emerging improved incinerator concepts **D7**
Containment *This technology refers to the concept of confining the waste within a specified land space in the ground and the potential environmental influences of this confinement.*	Develop and field-verify a protocol for predicting composition, rate of generation and total quantity of leachates from hazardous waste land disposal facilities **E1** Develop quick indicator test for predicting the attenuation and movement of leachates and leachate contaminants from land disposal facilities **E2**	Measure and evaluate the quality and quantity of volatile emissions from surface impoundments and land fills **E3**	Establish a 30-year test for a liner testing program **E4** Establish a 30-year field-testing program for fixation, stabilization, and bulk encapsulation of hazardous wastes **E5**	Evaluation of quick indicator methods for liner/ waste compatibility, permeability, durability and protocol for comparing predicted performance of alternative liner designs **E6** Evaluation of quick indicator tests for predicting leachability, durability, longevity, and compatibility of waste/process combinations **E7**	Investigate advanced liner designs **E8** Monitor industrial activities on land cultivation of hazardous waste **E9** Conduct demonstration of inactive mine storage/ disposal of encapsulated hazardous wastes **E10**

SOLID AND HAZARDOUS WASTE RESEARCH PLAN

PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
HAZARDOUS WASTE EFFECTS					
***Risk Assessment**	Perform health effects overview for one or two hazardous waste abandoned sites **F1**	Perform health effects overview for one or two hazardous waste abandonded sites **F2**	Establish a health effects emergency response capability to conduct epidemiological investigations of acute human exposures to environmental contaminants from hazardous wastes **F3**	Perform first set of epidemiological studies by emergency response team **F4** Develop protocols for biological screening methods for potentially hazardous wastes **F5**	Determine regulatory thresholds for all IARC and NCI known human, suspect human, and known animal carcinogens which pose a one-in-10^5 hazard to human health if specific carcinogen were a drinking water contaminent **F6** Validate analytical methods capable of detecting these carcinogens at the regulatory threshold **F7**
Transport and Fate	Develop analytical methods for use in subsurface environment to detect biochemical contamination using selected indicators **G1** Protocols for using chemical and isotope tracers in groundwater investigations **G2** Evaluate use of thermoplastic casing to prevent deterioration **G3** Evaluate economical techniques to restore wells which have failed **G4**	Evaluation of predictive methods for leachate and gas migration from solid waste landfills and from certain hazardous waste sites **G5**	Evaluate design criteria for transport characteristics of metals, organic and inorganic contaminants and viruses **G6**	Identify and assess transport/retention mechanisms for organic wastes **G7**	Field verfication of methods and transport mechanisms for organic and inorganic contaminants and their movement in soil **G8**

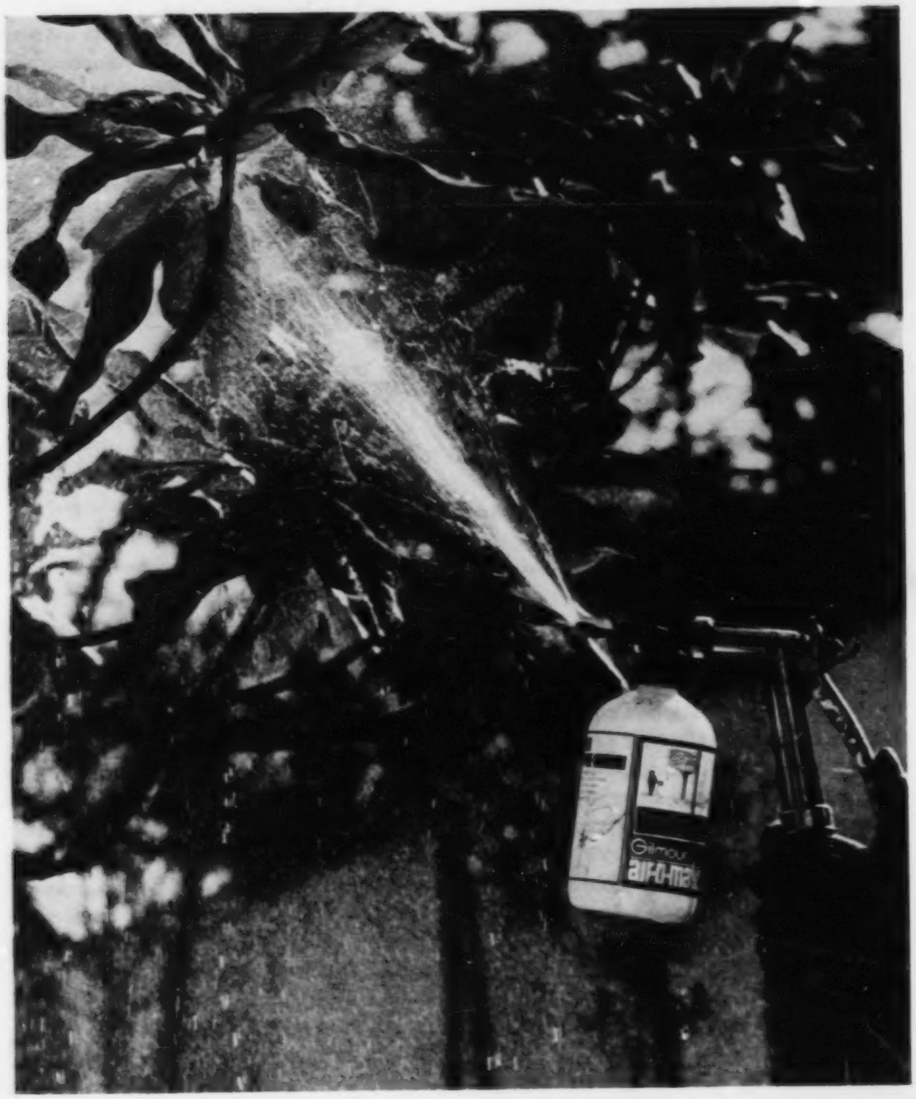
*EPA to encourage research along these lines funded by other agencies.

PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
HIGH VOLUME WASTES					
Mining					
This area is concerned with the characterization and identification of mining wastes		Design management standards for mining wastes **I1**	Characterize and design management standards for red and black muds. **I2** Characterize and design management standards for oil shale mining and beneficiation **I3**		Evaluate innovative waste handling and treatment technologies for mining wastes **I4**
Energy					
The utility industry wastes are characterized and their impact on the environment is determined		Determine design standard for management of coal ash and flue gas desulfurization waste **J1** Determine costs for utility industry compliance with RCRA performance standards **J2**	Determine what protion of coal ash and FGD waste is in the special waste category **J3** Determine coal pile drainage effects on groundwater **J4** Characterization and comparison of electric utility coal ash and FGD waste with industrial boiler waste; hog fuel ash; RDF ash; oil field steam generation FGD waste **J5** Determine design standards for management of geothermal energy waste **J6**		Evaluate innovative waste handling and treatment technologies for mining wastes **J7**

SOLID AND HAZARDOUS WASTE RESEARCH PROGRAM
HIGH VOLUME WASTES

PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
NON-HAZARDOUS WASTES					
Municipal Solid Wastes					
This area concerns the effect of municipal solid wastes on the environment and the potential for resource recovery of this waste. Therefore, it will be divided into Resource Recovery and Landfilling.					
Resource Recovery					
This subsection is concerned with the recovery of wastes from the municipal waste stream and the use of wastes-as-fuel.	Development and assessment of resource recovery from glass and plastic wastes **K1** Evaluation of impediments to economical resource recovery systems **K2** Priorities for resource recovery research **K3**	Develop improved technologies for forecasting quantities and composition of solid waste **K4** Preparation of RDF for cement kiln firing **K5** Environmental assessment of co-firing of waste with coal **K6**	Evaluation of resource recovery potential from hazardous and high volume wastes **K7**		Process and environmental evaluation of full-scale resource facilities **K8**
Landfilling					
This subsection is to assess the measures to be taken to measure and control the potential environmental problems from landfills.	Summary and assessment of leachate production **L1** Demonstrate surface capping as a remedial action at a landfill site **L2** Develop a manual of practice on impacts of solid waste disposal on surface and groundwater **L3**	Fate of heavy metals during landfill stabilization **L4** Monitor remedial site which was surface capped **L5** Develop a manual of practive on groundwater sampling techniques and municipal waste disposal sites **L6**		Develop leachate production forecasting technique to guide the design, operation,and permitting constraints for specific landfill sites **L7** Evaluate various control methods to minimize environmental impact of landfills subject to RCRA regulations **L8**	Evaluate various methods to stabilize landfills to mininize environmental impact **L9**

PESTICIDES



Pesticides will continue to play an important role in our economy. EPA research determines adverse health and ecological effects and develops means to reduce the dangers.

Pesticides play a vital role in our economy and in our lives. They help to create the abundance of food and fiber in our country, and protect the public health by controlling insects and other pests. But because pesticides are primarily designed to kill or otherwise affect the biological behavior of living organisms, they must be considered potentially hazardous. The hazards they pose are not only to humans but to other life as well, including wildlife and livestock. Pesticides, therefore, must be carefully controlled in the environment.

Some of the pesticides that were developed during or immediately following World War II were chemicals that persisted in the environment after application. Wide use of these pesticides in agriculture quickly followed. Today several billion pounds of pesticides are used annually in the United States; however, many of the newer pesticides are less persistent in nature. The near future, on the other hand, will see development of pest control methods which include biological controls and more degradable products.

Because of increasing awareness about the accumulation and effects of persistent pesticides, which have been found in air, water, soil, and human tissue samples, there is a great deal of public concern about the safety of these compounds. Since 1970, EPA has banned most uses of the most persistent chemicals (e.g., DDT, mirex, kepone, aldrin, dieldrin, chlordane, and heptachlor), and is now encouraging the use of integrated pest control methods, rather than rote chemical protective spraying.

Protecting the Public and the Environment

Laws to protect the public and the environment from the potential hazards of pesticide use are the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) as amended, and the pesticide amendments to the Federal Food, Drug, and Cosmetic Act (FFDCA). The FIFRA requires a premarket clearance by EPA for all pesticide products to be used in the United States. The FFDCA permits EPA to establish a tolerance (acceptable residue level) for pesticide residues in food or livestock feed crops.

The FIFRA (amended in 1972, 1975, and 1978) requires EPA to balance the risks and benefits of a pesticide's use. Manufacturers are required to send to EPA data about the risks of a pesticide's use; these data typically encompass toxicology (primarily studies on laboratory animals), chemistry, environmental fate, and fish and wildlife hazard studies. EPA has authority to refuse registration or, in cases of products already on the market, to cancel or suspend registration if the risks from certain or all uses of a pesticide are found to outweigh the benefits to society.

> EPA has banned most uses of the most persistent chemicals.

The amendments to FIFRA have given EPA two major tasks to accomplish: the reregistration of all pesticides now on the market and the classification of all pesticides into general use or restricted use. Restricted use means that a pesticide is to be used only by or under the supervision of trained, certified applicators. More than a million farmers and professional applicators have been certified to handle restricted-use pesticides, and more than 300 pesticide uses have been or are proposed to be restricted. EPA is now embarking on the massive job of reregistering some 35,000 pesticide products (made from about 1,500 principal active ingredients) in accordance with the most current scientific standards. An EPA proposal, with which Congress agreed and set forth in the 1978 FIFRA amendments, is that reregistration and future registrations be accomplished through development of a registration standard. The standard will enumerate all approved formulations, uses, and restrictions, and will be based on all relevant data about a pesticide's effects, including the same kinds of data now required for regulating new products but which have never before been collected for the older pesticides. This novel approach to pesticide registration offers the advantage of making only one comprehensive risk/benefit decision per chemical, rather than the resource-intensive and wasteful product-by-product approach taken in the past. Even so, the enormous task of developing registration standards for all pesticides will take approximately 10-15 years.

The Research Plan

We believe that to properly protect the public from unreasonable pesticide risks while at the same time assuring the continuing benefits from the pest control afforded by these compounds, a strong research effort is needed to provide a sound scientific basis for these regulatory activities.

The pesticides research plan focuses on data and techniques for assessing potential health and environmental risks, and techniques to minimize introduction of pesticides into the environment.

Developing Scientific and Technological Information to Help Protect Public Health and the Environment

Three basic elements are necessary to evaluate potential overall human health hazards and environmental hazards from pesticides: (1) identification of the population at risk; (2) assessment of population exposure; and (3) determination of adverse effects to health and ecology. Our pesticides research program is designed to provide scientifically sound, legally defensible, and publicly acceptable information to support decisions on pesticides.

Populations at Risk

The registered uses of a pesticide help to determine population groups susceptible to risks through direct exposure, including applicators, loaders, mixers, and formulators. If a compound is used on a food crop in a way that leaves a residue at harvest, however, then the general population becomes the population group at risk. The total volume of the chemical produced and its use is important in defining the overall size of the population at risk from it.

There are various population groups that may have unusual susceptibility to some compounds. These groups include the very young and the very old, who may be more sensitive to chemicals than median-age groups; women of childbearing age who should be carefully protected from compounds known to have teratologic effects; and persons acutely or chronically ill with certain diseases that may decrease resistance to the adverse health effects of pesticides. Once exposed to pesticides, some people experience reduced resistance to infection or to other forms of disease. Studies also indicate a relationship between nutritional status and susceptibility to chemical injury in experimental animals and, in a few instances, in humans. Pesticides also may interact with drugs, chemicals, and other pesticides. Knowledge of individuals' therapeutic, occupational, and other histories may therefore be important in defining population groups with unusual risks.

Certain plant and animal communities that occupy critical niches in ecosystems may also be especially susceptible to pesticides, and if these communities are harmed, entire ecosystems could be adversely affected. We will therefore also develop information on these plant and animal populations, particularly as they relate to human populations.

Determining Routes of Exposure

Both humans and animals are exposed to pesticides through dermal, inhalation, and ingestion routes; non-human organisms are also exposed through their food chains and the water, air, soil, or sediment in which they live. To assess the hazard a chemical poses, we must understand the magnitudes, duration, and timing of exposure to the pesticide that both humans and the environment experience. Exposure of the human population to pesticides occurs through occupational, dietary, or environmental routes.

Occupational exposure. Occupational exposure to pesticides occurs in a wide range of durations and frequencies with a variety of materials. The farmer may treat his crop only once or a very few times per season; the commercial applicator, spray pilot, or pest control operator, however, may use pesticides every working day during the year. Migrants and other crop workers may be exposed to pesticides on a regular basis. (B2, B4)

Measurement Methods

Although satisfactory methods to measure exposure are now available for some compounds (such as the chlorinated hydrocarbon pesticides), better methods are needed for the carbamate pesticides, among others. We will develop and validate techniques and protocols, with appropriate quality control procedures, for measuring amounts of pesticides in air, water, soil, sediment, tissue, and commercial products. Emphasis will be on multi-residue methods, collection devices, separation techniques, and advanced instrumentation applications, especially high-pressure liquid chromatography (HPLC) and gas chromatography/mass spectroscopy (GC/MS). Immunochemical and other innovative methods will also be explored. Studies will continue to develop advanced methods to increase sensitivity and resolution of our procedures and instruments. Special emphasis will be on development of methods for analyzing pesticides bound to soils and sediments.

Environmental exposure. The general population is exposed to pesticides through food, water, air, and possibly through other media. Although methods are available to estimate total exposure, we must develop additional methods capable of defining man's exposure to newly introduced pesticides in the various media.

Pesticides entering the environment can be transported through air, water, soil, sediment, and biota, including components of th food web consumed by man. Thus, data on routes of exposure are not only essential for gauging ecological effects but are also important in estimating human exposures. We will identify the important exposure routes for selected pesticide classes and for their major uses, and will then develop and validate techniques for estimating the amounts of pesticide chemicals that enter these exposure routes. (B1, B3, B5)

We also plan to study interactions of pesticide chemicals with air, water, sediment, and soil and the action of organisms on the chemicals. This will support development of test protocols for evaluating the environmental transport, transformation, and distribution of pesticides. We will characterize environmental interactions by determining the role of environmental factors (e.g., temperature) in controlling the rates and extent of the transformation. In accomplishing this, we will address: (1) sorptive processes in soils and sediments; (2) methods to predict light scattering and sorption in natural waters; (3) role of soil and sediment in pesticide chemistry; and (4) improved techniques for determining microbial degradation kinetics of pesticides in soil, water, and sediments. (B6, B8, B10)

The degradation of a pesticide in soils is one of the most important factors in determining the environmental impacts of that pesticide. However, little is known about how pesticides are affected by different soil types in different geographic locations. Degradation studies, therefore, should investigate the rate constants of hydrolysis and microbial degradation in selected soil systems to provide information that could be extrapolated to any soil system. (B9)

We are also concerned with the new pesticides such as growth regulators, juvenile hormones, and slow-release pesticides, that are coming into use. Transport and fate of such pesticides must be fully understood, since improper use could adversely affect beneficial organisms. (B7)

To comprehend the many simultaneous transformation processes of specific pesticides in marine, fresh-water, estuarine, and soil systems, we will construct controlled laboratory ecosystem models to test transformations. Semicontrolled field studies in outdoor natural settings will help validate our findings. We will construct and refine models that predict pesticide behavior until they attain the appropriate degree of utility, confidence, and reliability. (B9)

Biological transformation can be studied by determining the metabolism, rate parameters, and kinetics of detoxification in experimental animals. We will, therefore, develop mathematical models to predict the pharmacodynamics of pesticides as a function of structures and classes of pesticides. Such studies will also provide information about the fate, distribution, and accumulation of pesticides in organisms and tissues, and about the mechanism of action of pesticides.

We will also develop models to predict exposures of humans and other species to pesticides in the food chain. To develop such models, the following data are necessary: bioaccumulation characteristics, environmental process parameters, use patterns, physical/chemical properties of the pesticides, and input or loading of pesticides. (B3, B7)

Technology is being developed for integrating and analyzing pesticide data to estimate environmental exposure. The techniques will be consistent with those for non-pesticide toxic substances. (B7)

Adverse Effects from Pesticides

Health effects. There is a need for close coordination between exposure research and effects research to define the degree of hazard posed by exposure to a pesticide. For many pesticides, pesticide by-products, metabolites, and biotransformation products, experimental methods can now detect very low levels of chemicals.

Basic effects research involves study of the effect of pesticides on persons having been exposed to them. The studies with experimental animal models, selected to provide maximum information on hazards to man, will use both acute and chronic dosing for oral, dermal, and respiratory routes of exposure. (C1)

In addition to information on lethality and signs of intoxication, we will collect information on biochemical effects,including enzymes and gross histopathology. Special studies will include determining teratogenicity, mutagenicity, and carcinogenicity. We will emphasize development of improved protocols to provide more sensitive and more efficient testing methods than those now available. (C3)

In all of these effects studies, we will emphasize the correlation of any observed adverse effect with a known dosage level of pesticide or, where possible, with the level of a parent compound or its metabolite(s) in urine, blood, or body tissue. Because true doses to people are almost never known, such excretory or storage levels often provide the only means with which to compare the toxic level of an animal model with the actual exposure level in man. Also, damage to human tissues at early stages is difficult to measure, but excretory and tissue levels can be measured. When these levels are compared with the tissue levels and tissue damages in animals that have resulted from known exposure, more reliable extrapolations of both exposure and damage to humans may be made.

Damage to human tissues at early stages is difficult to measure.

Biological control agents are a special problem, since their potential hazard is not confined to the effects of the pesticides themselves, but involves, among other things, the possiblilty of mutation, biotransformation, or other change that could convert an insect toxicant into a mammalian toxicant. Since traditional toxicological methods are not adequate to assess the potential hazard of biological materials, such as insect viruses, bacteria, and hormones, standardized protocols must be developed to provide adequate and safe testing procedures for potental registrants who will develop new materials. (C6)

We will emphasize studies designed to provide improved methods for extrapolating animal test data to man, particularly in the area of mutagenesis. Research will include attempts to develop improved experimental animal models as well as procedures designed to yield more valid and meaningful mathematical models that can convert animal data to data applicable to humans. (C3, C5)

Environmental effects. There is no single toxicity test that can measure the effects of pesticide exposure on organisms, populations, and ecosystems. We will, therefore, develop protocols that include a tier system of biological testing to evaluate the effect or potential effect of pesticides on the environment. These tests must be developed in such a way that the resulting protocol can be transformed to data requirements for industry. (C10, C11) We will concentrate on:

- techniques and protocols to measure the acute, chronic, and "no-effect" levels, and ecosystem effects from realistic pesticide exposures;
- techniques for studying mechanisms of mutagenic, teratogenic, and carcinogenic effects of pesticides on sensitive organisms, and
- techniques for evaluating effects of biological control agents (such as juvenile hormones and viruses) on non-target terrestrial, fresh-water and marine organisms.

At present, the major criteria used to assess the risks or potential impact of a given chemical or pollutant complex are death and sublethal effects revealed by relatively short-term toxicity tests. These criteria, however, lead to laboratory results that may not predict subtle, long-term, or even acute effects in the actual environment. Despite their drawbacks, the criteria of death of test organisms and sublethal effects of pollutants (resulting from controlled laboratory exposure of test organisms to known concentration of pollutants) are the best available approaches to predicting the impact of pollutants, and, therefore, the best basis for formulating environmental quality standards.

Understanding these basic mechanisms may enhance predictions of effects and impacts.

Another research approach attempts to improve the predictive basis for the regulation of specific pollutants. This approach involves investigation of basic molecular, biochemical, physiological, cellular, and pathological mechanisms through which specific pollutant agents cause damage or elicit toxic responses in organisms (from microbes to man). Understanding these basic mechanisms may enhance predictions of effects and impacts of toxicants on organisms. Many examples in modern toxicology and pathobiology have shown how partial or complete elucidation of a basic mechanism of toxicity for specific toxicants has led to realistic predictions of an effect, control, or regulation, and a remedy for the exposed organism, e.g., organophosphate poisoning.

This research approach should not replace existing standard assay methods.

The objective of this investigative approach is to gain a complete understanding of how and why pollutants damage organisms. Partial understanding of the mechanisms, however, can be useful as well (i.e., an understanding of the nature of damage at the cell level, but not at the molecular level, may serve a useful prupose). This research approach should not replace existing standard assay methods, but should better explain the results obtained by those methods, as well as predict long-term effects that are not revealed by the standard empirical approach.

Integrated Pest Management (IPM). During the past several years, a conscious effort to develop and demonstrate effective strategies to manage pests had been made. Since such strategies need to be based on sound biological, ecological, environmental and economic information, the IPM program is designed to couple ecological and biological information with economically acceptable practices to keep the pest populations at levels that do not cause economic hardship to food producers or urban dwellers. The program is fully coordinated with the U.S. Department of Agriculture (USDA).

The goal of our IPM research is to combine non-chemical and chemical controls to reduce pesticide use while maintaining food and fiber production and quality. Information about IPM control strategies and techniques will be distributed to agricultural and urban users by the extension service of the USDA and through trade publications, consultants, and technical and professional societies.

While researching pest management, we will continue to study individual crop ecosystems. Every crop has its own special set of research needs and its own unique pest management problems. Crops that are most extensively grown and that require heavy pesticide use will receive the major research effort. Crops that are being studied include cotton, alfalfa, soybeans, apples, rice, and corn. Some insect/multicrop interactions have also been studied in this program.

Every crop has its own special set of research needs.

Major insect pests will be indentified for intensive study first. Then, for each crop, insect population dynamics and biological and ecological influences will be carefully determined, and their interactions with the plant community identified. The effects of natural field control mechanisms such as predators, temperature, moisture, and diseases will also be identified and studied. The research information will then be incorporated into mathematical models so that control techniques and control strategies may be developed for a range of situations in each crop system. (D1 through D5)

Since the use of pesticides within and around homes and urban work places is a continuing concern, especially when people are unaware of potential dangers from close proximity to hazardous pesticide compounds, we will investigate possible alternative controls for pests found in and around urban structures. Improved sanitation in conjunction with trapping and the use of predator insects, animals, and birds is the present emphasis of the program. Information will also be gathered on pesticide-use practices and social attitudes regarding pests and pest management in urban situations.

Quality Assurance for Pesticide Measurements

EPA uses the best available measurement methodologies to determine pesticide exposures, monitor environmental and human pesticide burdens, and assess pesticide effects. Data that results from the measurements are used in decision-making and therefore their precision and accuracy must be acceptable to all parties affected by EPA's decisions. A quality assurance program provides measurement systems of verified performance characteristics and quality control mechanisms that assure continual operation of the measurement systems within verified performance limits.

A repository of pesticide chemicals of known purity is maintained to supply analysts with suitable reference and calibration materials. Pesticide chemicals incorporated into a variety of environmental materials (biological tissues, soil, or water) also serve as reference samples for maintaining the satisfactory performance of measurement systems. Analytical supplies, rigorously examined for compliance with quality control specifications, are furnished to help the national monitoring network develop comparable data on human and environmental pesticide residues.

Major insect pests will be identified for intensive study first.

PESTICIDES RESEARCH PLAN

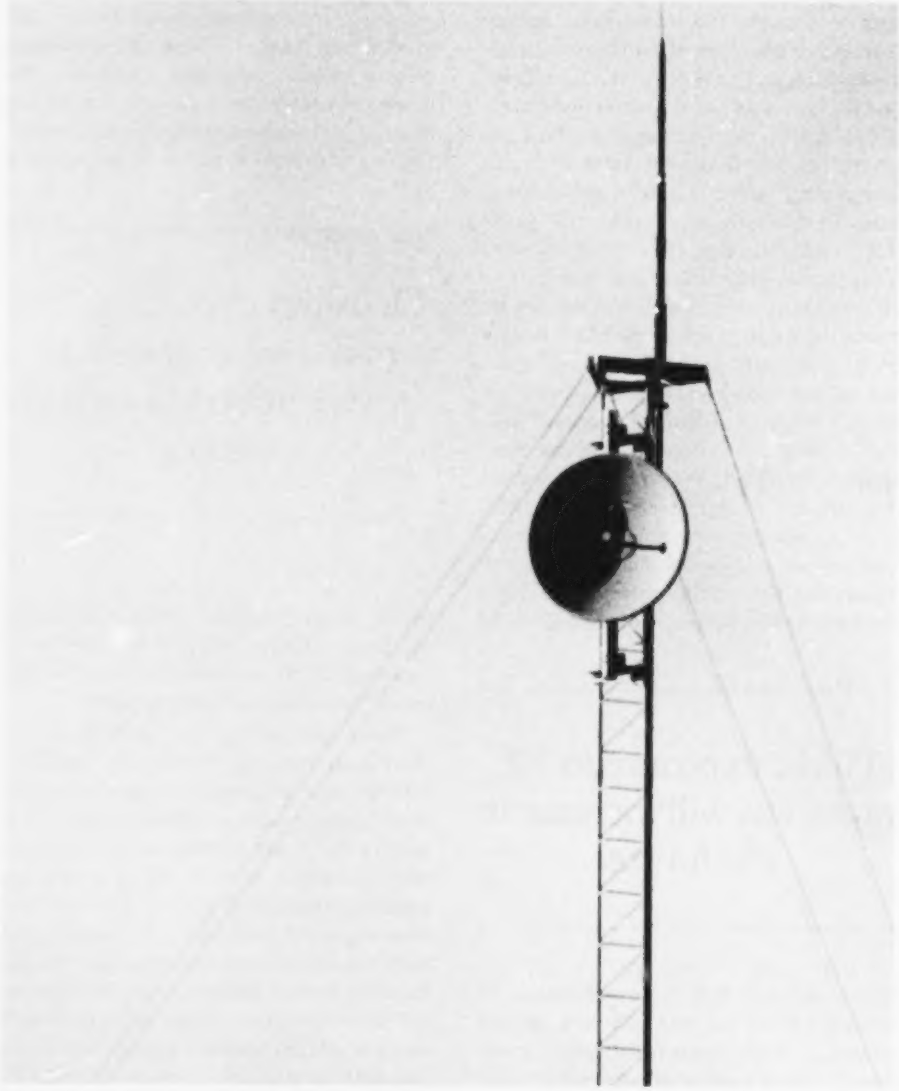
PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
Populations at risk	Technical assistance in measuring human environmental exposures **A1**		continuing		
			Studies of specific uses of pesticides in agriculture, homes and gardens to evaluate human exposure potential **A2**		
			Complete field study assessing fate and effects of pesticides in an orchard eco-system **A3**		
			Complete studies of natural ecosystems to determine survival, growth, reproduction and gross pathological changes in community structure and test organisms **A4**		
Determining routes of exposure	Estimates of environmental exposures for high interest pesticides, selected by OPP, under various hypothetical agricultural application regimes **B1**		continuing		
		Assist in developing guidelines for estimating pesticide exposures of various occupationally and environmentally exposed groups for use by registrants **B2**	Analytical technology for evaluating human exposure to biological agents for controlling pests **B3**	Evaluate the effectiveness of selected protective equipment in reducing pesticide exposures **B4**	New validated methodologies for determining human exposure to pesticides through dermal and inhalation routes **B5**
			Improve protocols for testing pesticide transformations in water **B6**		Improve methodologigies for multi-media estimates of pesticide exposures.

PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
					Improve test protocols for transport and fate of pesticides in marine and coastal waters. Improve methods for assessing pesticide exposures in terrestrial environments Improve protocols for testing leaching of pesticides in soils
Adverse effects of pesticides **a) Health effects**	Toxicological and chemical scientific data to support regulatory efforts **C1**	———	continuing ———	———	———→
		Improve validated analytical methods and good laboratory practices for detecting and measuring pesticides whose health effects are to be determined **C2**			Quantified health effects of generic chemical pesticides now registered. **C4**
		New toxicological methodology for evaluating the effects of biological pest control agents **C3**	Evaluate health effects of biological control agents **C6**		Validate short-term bioassay testing program for estimating genetic or long-term toxicologic responses to pesticides **C5**
b) Environmental effects	Test results of acute and chronic toxicity of pesticides to aquatic and estuarine organisms **C7**	———	continuing ———	———	———→
		Data on the effects of encapsulated pesticides on test organisms **C8** Data on the toxicological impact and bioaccumulation of wood preservatives in terrestrial ecosystems **C9**	Methodology for studying and data on subacute, chronic and reproductive impact of ingested pesticides in avian species **C11**	Microcosm methodology for determining the fate and effects of pesticides in terrestrial ecosystems **C12** New or improved methods for determining acute and chronic effects of pesticides on marine organisms and ecosystems **C13**	

PESTICIDES RESEARCH PLAN

PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
		New or improved methods for determining acute and chronic effects of pesticides on marine organisms and ecosystems **C10**			
c) Integrated pest management	Publish strategies and tactics of insect pest control for pome and stone fruits, alfalfa, cotton, pine bark beetles, soybeans and citrus **D1**	IPM tactics for control of musk thistle **D2**	IPM tactics for control of soil anthropods in corn **D3**	Demonstrate regional multi-crop IPM strategy with determination of environmental risks and bnefits **D4**	Interim results of 15 university IPM projects on soybeans, and apples **D5**
Quality Assurance for Pesticide Measurements	Analytical support to national epidemiological monitoring activities **E1**		continuing →		
	Maintain and upgrade repository of pesticide calibration materials **E2**				
			Complete performance evaluations of analytical procedures for alkyl-phosphate in urine and toxaphene in soil **E3**	continuing →	
			New special pesticide reference materials for alkyphosphate in urine and toxaphene in human tissue and soil **E4**		

NONIONIZING RADIATION



We are exposed to an increasing number of radiofrequency sources. EPA is examining potential biological effects of prolonged exposure to this type of radiation.

Nonionizing radiation, NIR, is a general term to describe electromagnetic energy radiated at wavelengths longer than ultraviolet light. The NIR spectrum includes visible light, infrared rays, radio frequencies (RF), and the low frequencies used for electric power transmission and distribution. Our present concern is with nonionizing radiation at frequencies from 1 to 10^{15} Hertz (Hz), especially the VHF and microwave frequencies, which fall into the 300 to 300,000 MHz range. Such frequencies are emitted by a variety of sources. Every day we are exposed to broadcast TV, radio waves, and radiations from such commonplace items as walkie-talkies, radio-telephones, CB's, traffic radars and microwave ovens. Less apparent but equally as pervasive are sources that include tracking and weather radar systems, satellite communications systems, medical diathermy units, industrial RF heat sealers and high voltage power lines. Public exposure to RF radiation will increase in the future, not only from the expanded use of existing sources but also from new sources such as a potential space-based electric power supply system capable of transmitting solar power to earth via microwaves.

> Public exposure to RF radiation will increase in the future.

In recent years, there has been increasing public interest in the potential biological effects of RF radiation. Congressional hearings on radiation health and safety, inquiries into the irradiation of the U.S. Embassy in Moscow, and challenges to the construction of high voltage power lines all point to a growing general concern over the effects of nonionizing radiation exposure.

RF energy reaching an organism is measured by power densities. Power densities are expressed as the number of milliwatts on an area of one centimeter squared (mW/cm^2). Scientists agree that for frequencies above 10 megahertz power densities exceeding 100 mW/cm^2 are likely to cause adverse human effects such as cataracts. Currently, the heating of body tissue is the only mechanism that can explain most of the effects resulting from high-level RF exposure. Other research points to the possibility that some of the effects associated with chronic, low-level exposure to RF radiation, however, may result from nonthermal mechanisms.

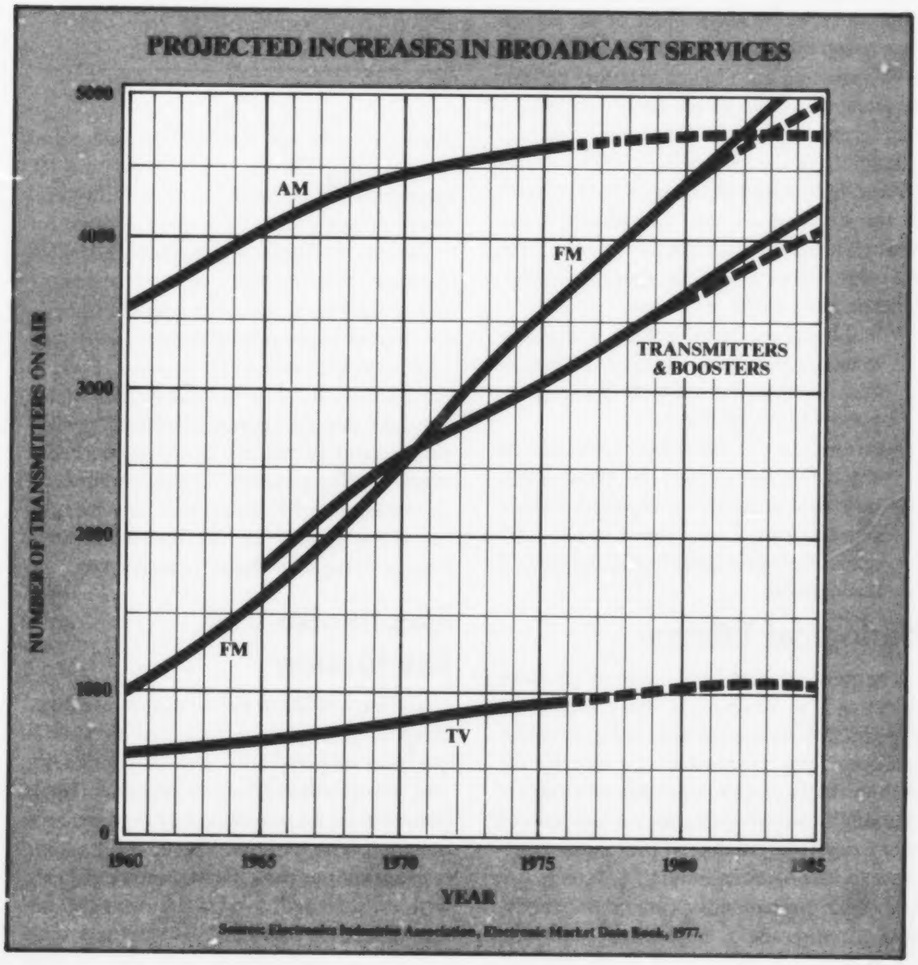
> Densities exceeding 100 mW/cm^2 are likely to cause adverse human effects.

Based upon the thermal mechanism, the American National Standards Institute (ANSI), a public organization concerned with worker safety, decided that there should be a limit on the power density to which a worker may be exposed. In 1966, this group recommended a voluntary guideline of 10 mW/cm^2 based upon estimated rises in tissue temperature from microwave radiation. Soviet and East European scientists, however, have set far more stringent occupational standards based on alleged low-level effects. The Soviet standard, for example, is currently about 10 μW/cm^2 (*micro*watts per cm^2) depending upon the frequency, 1,000 times lower than the level recommended by ANSI. Still, a recent EPA study calculated that 99% of the U.S. population is continuously exposed to lower levels of RF radiation than even that which is allowed by the Soviet standard. Even the RF levels generated by FM radio and UHF TV transmitters, the most significant U.S. sources of radio frequency radiation emitted into the general environment, are relatively low except at locations very near to the source's antenna.

Recent results from EPA and other U.S.

research into RF radiation are beginning to demonstrate the need for far greater caution than we have previously thought necessary. These findings indicate that at relatively low levels, chronic exposures to RF radiation can produce a variety of effects in laboratory animals. Morphologic changes in brain tissue, immunological and behavioral changes and blood chemistry effects have been observed in animals exposed to frequencies of 425, 918, and 2450 MHz at a variety of power densities at or below 10 mW/cm². Recent experiments studied the interactive effects between microwaves and a commonly used tranquilizer. It was demonstrated that the behavior of rats was modified when they were exposed to an average power density of 1 mW/cm² at 2450 MHz while under the influence of the tranquilizer. However, no behavior change was noticed in rats exposed to either the microwaves or the drug alone. Hematological and morphological changes have been reported in the spleen and thymus of mice exposed to pulsed microwaves (3105 MHz). Immunological changes have been observed in test animals at 5 mW/cm², with yet other studies demonstrating the increased release of calcium from the brain resulting from exposures to amplitude modulated (AM) 147 MHz radiation at 0.8 mW/cm². Calcium is important to the brain in that it helps exert control over the nervous system.

These results all combine to suggest that at certain frequencies the 10 mW/cm² standard


PROJECTED INCREASES IN BROADCAST SERVICES

Source: Electronics Industries Association, Electronic Market Data Book, 1977.

does not provide an adequate safety margin, and today ANSI is proposing to lower the standard to 1 mW/cm^2 in the frequency range for human resonance (30-300 MHz), i.e., the range within which man absorbs the maximum energy.

Although OSHA has endorsed the ANSI voluntary standard, there is at present no legally enforceable occupational or environmental exposure standard. Only the Department of Defense, on its own initiative, has prescribed the ANSI standard for its personnel. Recently, however, OSHA began its process to develop an occupational exposure standard. Similarly, EPA's Office of Radiation Programs has announced its intention to develop environmental RF radiation guidance for the general public by 1981.

EPA needs scientifically sound data to support this planned environmental guidance. Ultimately a full assessment of the health risks posed by continuous low level exposure to RF radiation must be made before definitive guidance can be given. However, this is a long-term prospect, and the interim guidance, scheduled for development in 1981, will be derived from a less than complete data base. In the near term, our multidisciplinary research program is designed to provide EPA and other concerned federal agencies with an understanding of the following:

- biological effects of prolonged exposure to environmentally significant frequencies—such as FM and UHF-TV frequencies (A1 through A7)
- mechanisms of interaction between NIR and biological systems (B1 through B9)
- potential effects in exposed human populations as determined by epidemiological and clinical studies (C1 through C4).

Biological Effects

The primary NIR health effects research objective is to demonstrate the existence of reproducible biological effects and to establish dose-response models. To identify the health effects of exposures to environmentally significant RF radiation, we will conduct interdisciplinary studies of prolonged exposures to low-level radiation (A-1, A3, A5, A6). Such studies will examine the behavioral, immunologic, hematologic, physiologic, reproductive, genetic and teratogenic consequences of prolonged pre- and postnatal exposure to include multigenerational exposures. This research will be aided by improved dosimetric analyses employing infrared thermography and by computer modeling of thermal energy distribution in the human body (B1). Effects from pulsed (radar) radiation versus continuous wave (broadcast) radiation will also be examined (A2).

To interpret how effects in animals may relate to this health risk posed to man, we need the tools and methods to detect and monitor subtle changes. On the theory that RF exposure may manifest itself as a low level stressor, we plan to develop indices for evaluating the degree of stress induced by RF exposure (B6). We will also try to determine how temperature, humidity and other physical factors such as amplitude-modulation interact with microwaves to produce synergistic effects (A4, A7, B8). Recent studies have indicated that the operant behavioral performance rates in rodents decrease markedly when slightly elevated air temperatures are combined with RF radiation at power densities of 5 to 15 mW/cm^2. Primate studies will attempt to replicate these findings (A4).

We need the tools and methods to detect and monitor subtle changes.

Mechanisms of Interaction

To direct efficient experimental investigations it is important to know how NIR interacts biophysically and biochemically with living systems. Such an understanding is also essential for making valid assessments of potential NIR hazards. Therefore, a major emphasis of our work over the next five years will be directed toward identifying the mechanisms by which NIR interacts with biological systems, to include determinations of how NIR may damage cell membranes or cell biopolymers (e.g., enzymes and proteins) (B2, B3, B4).

For biological tissue to show any effect it must absorb energy from NIR. To determine the relationship between NIR frequency and such energy deposition in tissue, we are scanning a range of frequencies from 250 to 8000 MHz to examine how they interact with cellular and subcellular systems (B5, B9). Results from this continuing effort will assist in identifying those discrete frequencies that may produce biological effects. This will subsequently help us in establishing the focus of future animal studies (B7).

We know that nonionizing energy is not absorbed uniformly by biological systems; rather, it is distributed in patterns of concentrated energy termed "hot spots." The physiological significance of "hot spots" in critical tissues will be examined by exposing rodents and monkeys to chronic, low-level NIR and studying their physiological, behavioral and thermoregulatory responses (B6).

The central nervous system has been identified as a prime target for the effects of NIR. Further central nervous system research will be concerned with the effects of NIR on the energy production and metabolism of the brain, and on the interaction of NIR with neural membranes (B3). We will continue to be concerned with extremely low frequency AM exposures which have been found to be effective in inducing the loss of calcium from brain tissue (B8).

Nonionizing energy is not absorbed uniformly by biological systems.

Human Studies

Our primary concern is with the effects of human exposure to NIR at very low levels. Epidemiological and clinical studies will be conducted to determine the effects of RF radiation exposure in human populations. A study in Portland, Oregon, to be completed in 1980 (C2), will provide information about the possible correlations that exist between cancer incidence and current urban, ambient RF densities. A study of men exposed to radar during World War II will provide insights into the association between the prolonged exposure to pulsed, microwave radiation and its long-term effects, particularly as they relate to longevity and cause of death (C3).

Human studies research will increase in this program over the next 5 years.

It is anticipated that human studies research will increase in this program over the next 5 years. Prior to further epidemiological work, however, we must identify and characterize potential study populations for their suitability for follow-up and the availability of exposure estimates (C1). When we have this information, we will be ready to more confidently conduct epidemiological and clinical investigations (C4).

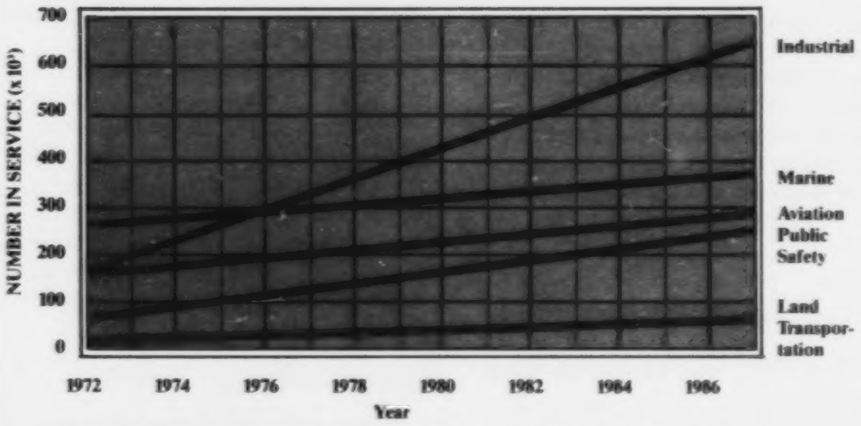
Coordination

Although our research program is planned primarily to support the specific regulatory needs of EPA, there are a number of research areas and needs common to all involved federal agencies. EPA is an active participant in several bi- and multi-agency activities. Among these is the Interagency Regulatory Liaison Group (IRLG). This Group, comprised of EPA, FDA, OSHA, and CPSC is charged with coordinating the regulatory and research activities of those agencies with potentially overlapping authority. The Radiofrequency Microwave Committee of IRLG is composed of representatives from EPA, FDA, and OSHA with observers from FCC and NIOSH. The National Telecommunications and Information Administration, with the assistance of EPA and other federal agencies, is working to design a government-wide research program in nonionizing radiation health effects. This BENER (Biological Effects of Nonionizing Electromagnetic Radiation) task force has developed a set of seven research objectives common to all federal agency programs. These are to:

- determine population exposure;
- determine energy absorbed;
- determine the biological consequences of exposures;
- develop instrumentation and exposure measurement systems;
- conduct risk assessments;
- conduct impact assessments; and
- recommend control measures.

These objectives provide a framework within which EPA-specific research can be developed, and it is expected that their fulfillment will lead to a sounder basis for regulatory decisions. EPA is also closely associated with DOE, both as manager of the Satellite Power System Microwave Health and Ecology Program, and as a member of the Interagency Group on High Voltage Transmission Lines.

PROJECTED INCREASES IN SAFETY AND SPECIAL RADIO SERVICES



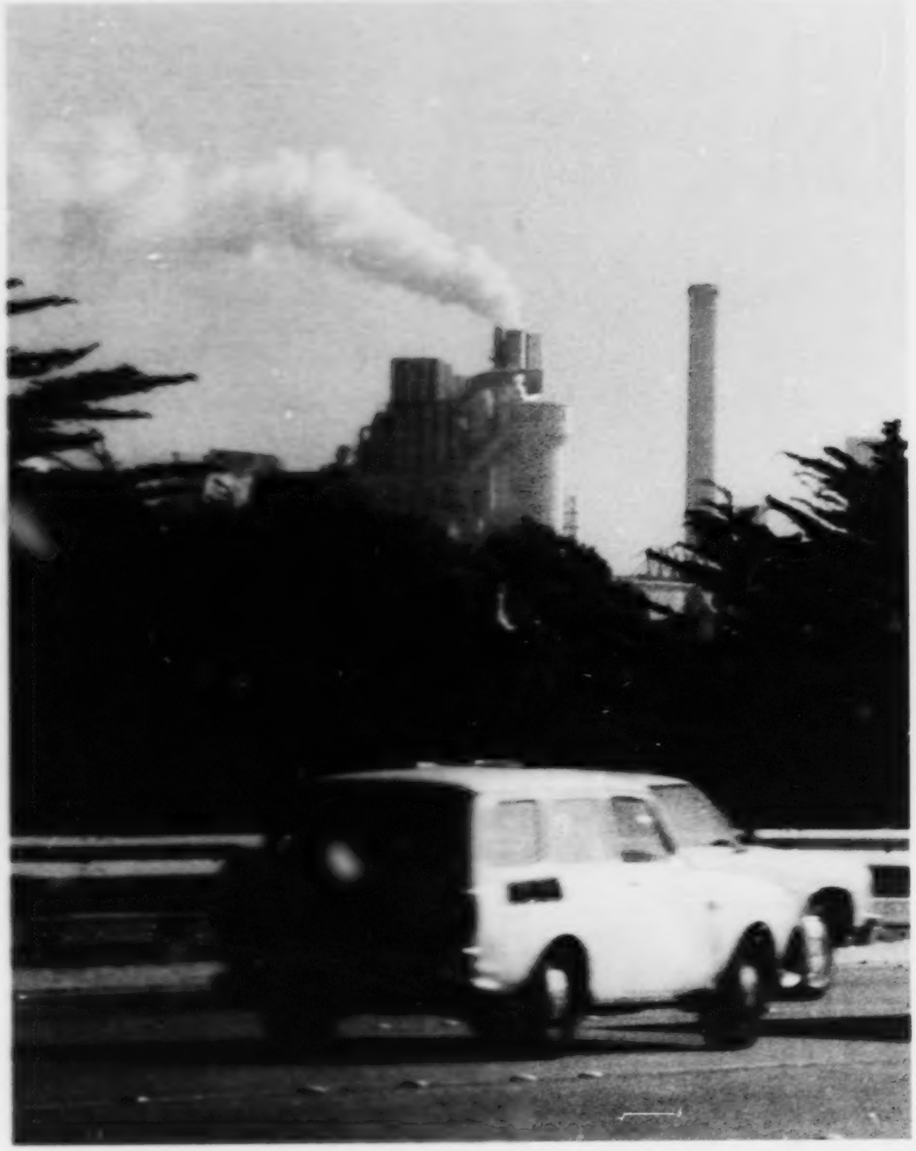
(Primarily Medium Power Base Stations But Includes Ships and Aircraft: Low Power Mobile Transmitters Generally Not Included)

Source: Electronic Industries Association, Electronic Market Data Book, 1977

NON-IONIZING RADIATION RESEARCH PLAN

PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
Long Term Low Level Exposure Studies Biological Effects	Health effects results from tests on rats chronically exposed to 915 MHz **A1** Relative immunologic effectiveness of pulsed versus CW radiation at VHF-TV frequencies **A2**	Identify the dominant lethal/mutagenic effects in rats of continuous prolonged exposure to 915 MHz **A3** Findings on the influence of temperature and humidity of operant and spontaneous behavior of rodents and primates of FM frequencies **A4** Effects of intrauterine and postnatal exposure to 2450 MHz on infant mortality in squirrel monkeys **A5**			Pathology results from lifetime exposures of mice of 2450 MHz **A6** Results from simultaneous FM and UHF-TV frequency exposure of rodents **A7**
Mechanisms of Interaction	Internal temperature profile in exposed animals **B1** Determine the effects of radio frequencies on biopolymers using the spectrophotometric technique **B2** Effects of RF radiation on neuronal membrane **B3**	Determine the effects of RF membranes using the fluorometric technique **B4** Determine absorption spectra of molecular, cellular and tissue samples exposed to frequencies ranging from 250 to 8000 MHz **B5** Evaluate the Selye Syndrome aspects of exposure **B6**	Identify the range of power levels at which biological effects occur **B7** Determine the range of AM frequencies at which biolobical effects occur **B8** Determine the biological absorption potential of frequencies in the 25-8000 MHz range **(continuing)** tie to bioeffects **B9**		
Human Studies	Identify and characterize potential study populations **C1** Findings on the frequency with which tumors occurred for high and low ratio emission densities in the Portland, Oregon area **C2**	Effects of exposure to radar during World War II **C3**	Clinical investigations of persons prior to and during occupational exposure **C4**		

NOISE RESEARCH

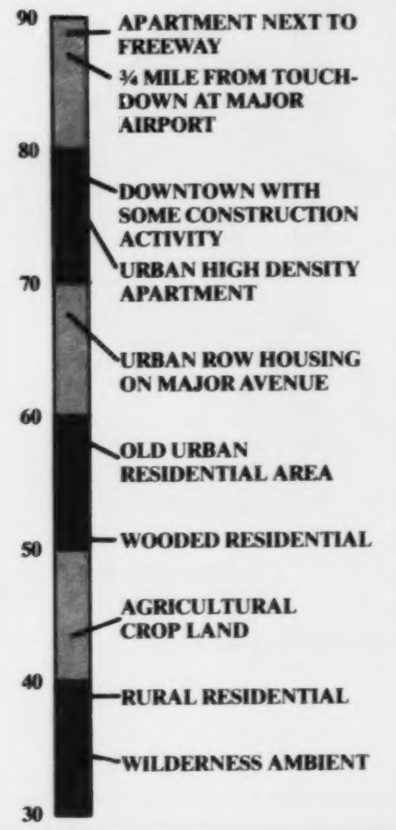


Noise surrounds us. EPA is studying possible health effects from noise and is developing methods to diminish the general din.

Recent data demonstrates that a substantial number of Americans are exposed to levels of aircraft and road noise well in excess of the L^{*}_{dn} = 55dB identified by EPA as the level necessary to protect the public health and welfare. Today, over 100 million Americans are exposed to traffic noise of L_{dn} = 55dB or greater, and over 20 million are exposed to L_{dn} = 65dB or greater. It is estimated that approximately 40 million Americans are exposed to aircraft noise of L_{dn} = 55dB or greater and 5 million to L_{dn} = 65dB or greater.

These figures represent a marked increase in the number of Americans exposed to various noise levels in the last ten years. Over the last two decades, there have been significant increases in the number of noise sources. There are more cars, trucks, motorcycles, and other vehicles on our highways than ever before. There are more office typewriters, more houses equipped with air conditioners and noise producing "labor-savers," and more industrial plants.

> Over the last two decades, there have been significant increases in the number of noise sources.



EXAMPLES OF OUTDOOR DAY-NIGHT AVERAGE SOUND LEVELS IN dB MEASURED AT VARIOUS LOCATIONS.

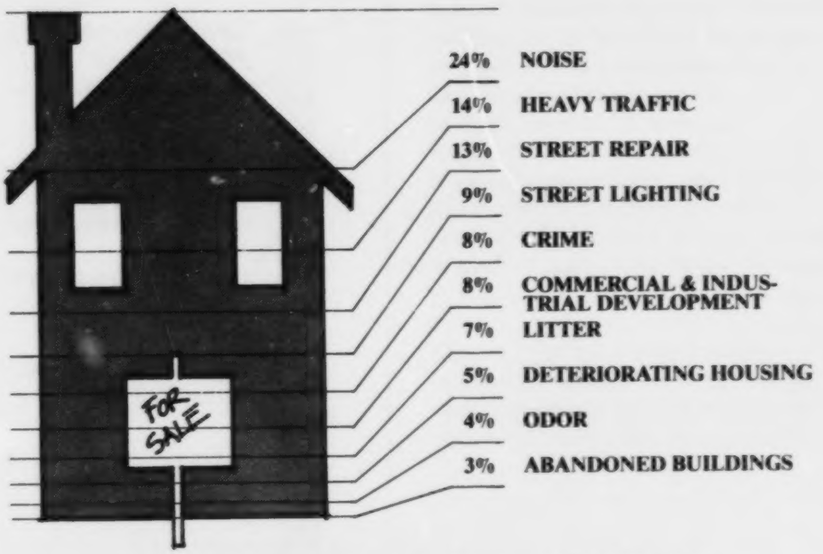
In EPA's 1976 *Urban Noise Survey*, it was found that generally, no one noise source stood out in peoples' minds. Rather, in areas away from the direct impact of freeway or aircraft noise, most people thought of community noise as a general din, made up of many sources rather than one or two. But when noise sources were cited by those surveyed, vehicle noise sources were most often mentioned, particularly motorcycles, large trucks and cars. In the immediate vicinity of airports, aircraft noise was the major complaint.

Although certain noise sources are perceived as more annoying than others, it is the combination of the total number of sources that determines an environment's noise level.

Mission

EPA has a mandate to protect the population from noise pollution that may jeopardize public health and welfare. The Noise Control Act of 1972, as amended by the "Quiet

*L_{dn}, known as the day-night sound level, is a 24-hour measure of noise weighted to consider certain annoying frequencies (A-weights) and noises that occur during nighttime quiet.



UNDESIRABLE NEIGHBORHOOD CONDITIONS: UNITED STATES COMPARATIVE RANKINGS. 1976

Communities Act of 1978" (PL 95-609), stipulates that specific and increased knowledge concerning the effects of noise on people is essential for EPA to carry out this mission. Specifically, EPA is authorized to:

- Coordinate all federal agencies' programs that relate to noise research and noise control;
- Establish federal noise emission standards for commercial products;
- Assist communities in developing and implementing a noise control program;
- Provide information to the public regarding the hazardous effects of noise and the noise levels associated with such effects.

Over the past few years EPA has gained extensive experience in monitoring, coordinating and conducting research on noise effects and noise control. This research has been primarily for and with other federal agencies.

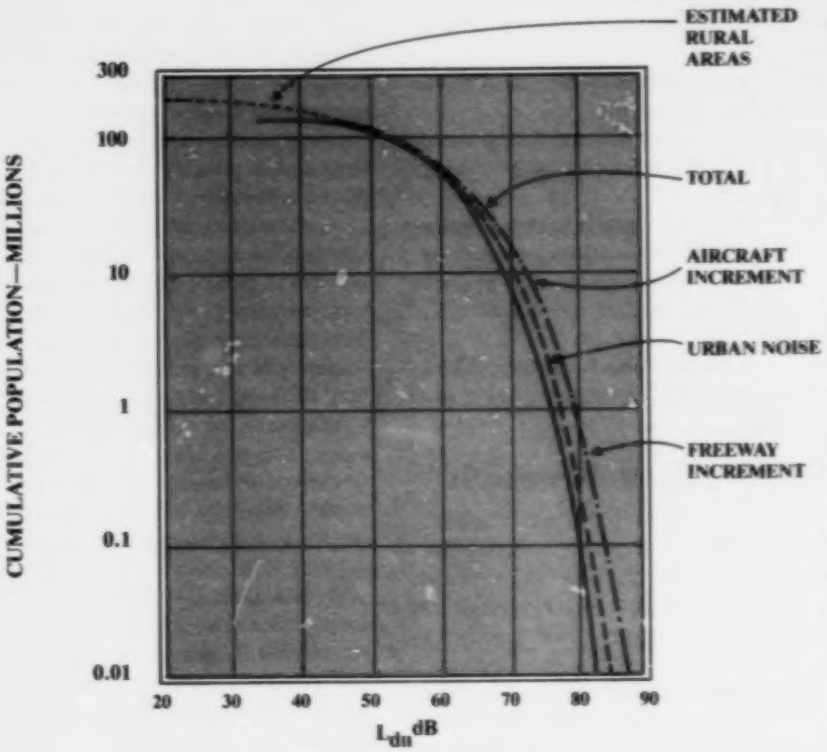
The EPA noise research program, administered by the Office of Air, Noise and Radiation, is designed to:

- Improve the health and welfare noise data base, refine existing criteria, and develop quantified non-auditory dose/response criteria;
- Fill in research gaps and deficiencies to obtain a thorough understanding of the health implications of noise, and to assure that health benefits can be properly ascribed to all noise control actions taken on federal, state, and local levels;
- Develop noise control methods and technologies.

In general, noise has several effects:

- Direct effects on the auditory system;
- Indirect effects on health (non-auditory);
- Effects on social well-being and economic factors such as productivity;
- Effects on the overall quality of life.

Noise abatement would result in reductions of hearing loss, reductions of non-auditory health effects, decreases in speech interference, and decreases in sleep disruption. It would increase learning by children living or studying in a setting with high noise levels,



RESIDENTIAL NOISE ENVIRONMENT OF THE NATIONAL POPULATION AS A FUNCTION OF EXTERIOR DAY-NIGHT AVERAGE SOUND LEVEL.

increase worker productivity, and, to some extent, it would lessen incidents of social disruption. Also, the reduction of noise could be expected to reduce people's general annoyance levels and, thus increase the subjective well-being. In short, noise abatement would enhance the quality of life.

Current State of Health Effects Information and Criteria. The effects of noise on learning, work performance and productivity, and social behavior are relatively well-documented, and dose-response relationships can be developed in the near future. Limited dose-response effects criteria are already available for noise-induced hearing loss, speech communication interference, community annoyance, and sleep disturbance. These relationships and criteria are not static however, and a substantial portion of the current EPA research program is directed at their refinement.

Use of Health Effects Information and Criteria. Adequate health effects information and criteria form the bedrock upon which any environmental regulatory program stands. For noise, emissions limits will be set only after careful consideration of such information, and only after careful examination of related dose-response criteria. In its noise research program EPA puts this health effects information and criteria to four basic uses:

- To support EPA product regulations and labeling action;
- As an essential rationale for the development of community noise control programs;
- To develop a concise, accurate up-to-date public information program designed to communicate the possible health and welfare effects of noise exposure;
- To provide support to other federal agencies in implementing their programs.

Health Effects Research

The most widely researched, best documented effects of noise relate to hearing loss, the most prevalent occupationally-induced disease. (A1) Non-auditory health effects however, have not been well-researched in the United States. While the annoyance effects of exposure to different levels of noise is well documented, the underlying physiological and psychological effects are still unclear, though it is currently believed that noise acts as a biological stressor. As such, it produces or contributes to effects on the body that are typical of "stress diseases" including hypertension, other cardiovascular ailments, ulcers, migraine headache, etc. These effects however, have not been thoroughly quantified, nor has it been proven whether they become chronic after protracted exposure.

> It is currently believed that noise acts as a biological stressor.

Since 1977, EPA, with co-support from NIH-NIEHS, has been sponsoring primate research on the consequences of long-term exposure to "realistic" noise exposures. One key finding to date indicates a sustained 30% increase in blood pressure of primates as a result of exposure to noises similar to those encountered daily by millions of Americans. These increases in blood pressure show no indication of returning to normal levels even after a full month of post-exposure quiet.

Health effects assessments that indicate that special emphasis should be placed on research on parts of the body other than the ear were completed in 1979 by a Federal Agency Noise Effects Research Panel, the National Academy of Sciences' Committee on Hearing and Bioacoustics, and the International Commission on the Biological Effects of Noise. This non-auditory research is needed to expand the existing cardiovascular literature (primarily Eastern European) which, while strongly suggesting an association between high noise exposure and hypertension, falls short of actually demonstrating a cause-effect relationship. The program will thus address those areas where there already is some evidence that long-term exposure may result in damaging effects. (A2, A3, A4) Included are studies of:

- Noise as a possible factor in cardiovascular disease;
- Occupational and social noise exposure to determine whether chronic non-aural health effects result;
- Special adverse responses to noise in children — including cardiovascular effects, cognitive and social development;
- Reproductive and fetal effects of noise exposures in women;
- Endocrinological and immunological effects;
- Adverse health effects of sleep deprivation and disruption caused by chronic exposure to noise;
- Interactive effects of other factors with noise, such as chemical and physical agents, and other stressors;
- Other studies of highly exposed groups in the area of stress related morbidity;
- Human response to aversive noise exposures.

The results obtained from these studies conducted over a period of years should enhance our health and welfare data base and help generate criteria to better assess noise control measures and their alternatives.

By 1985 other noise effects and human response criteria will also be generated and/or refined for other body systems, for reproduction, for children, for sleep interference, and for general health consequences.

Noise Control Technology

A fundamental understanding of the source of machinery and construction equipment noise, surface transportation noise, and aviation noise exists. However, in many situations it has been impossible for industry to introduce quiet machinery because such equipment does not exist. In addition, noise control methods must still allow equipment to meet high productivity requirements.

Many of the principal sources of noise associated with surface transportation vehicles (e.g., diesel engines, tire-roadway interaction, and wheel-rail interaction) are common to many classes of vehicles. Thus, the ability to significantly reduce the noise from these few principal sources would result in reductions of a great many specific noise sources.

Past technology has enabled the aircraft industry to make major gains in reducing aircraft noise. Additional gains can be expected with the application of present technology. If still greater progress is to be achieved in the future, however, more must be understood about the precise nature of such noise.

Improved noise control technology must be developed and applied to new automobiles and trucks.

Surface Transportation Noise. Recent studies by the U.S. Department of Transportation and EPA have indicated that unless remedial action is taken, the population exposure to environmental noise due to surface vehicles will increase substantially. To stave off potential community noise control actions as has been experienced at airports—for example, the curfews, limited operations, and use restrictions—improved noise control technology must be developed and applied to new automobiles and trucks.

The EPA highway noise research, development and demonstration program, involves the near-term development and testing of noise control methods in internal combustion reciprocating engines (B6), and in medium and heavy duty trucks. (B2, B5, B7)

Another effort will determine whether reliable methods can be developed to predict the relative noise contribution from individual tire design parameters, including materials, and whether such predictions can be used in tire design to reduce noise generation without compromising safety or ride characteristics. (B3, B4)

Aviation Noise Research. Today, more than 60% of the total federal funding in noise research has been for programs aimed at reducing aircraft-generated noise. In the past, significant reductions in aviation noise were accomplished through the introduction of the high bypass ratio turbofan engines and duct acoustic liners to suppress fan tones. Future progress in aviation noise reduction, however, will be more difficult to achieve because no single major source remains. Rather, today a wide variety of noise sources contribute relatively equally to total aviation noise. Thus, research must now be directed at these noise sources concurrently.

What is known is that the trend of near-term relief from aviation noise through applications of previously demonstrated technology will reverse as the aviation industry grows unless additional noise control actions are implemented. These future actions depend heavily upon current research into such facets of aviation noise as advanced, quiet, efficient small propellers for general aviation aircraft.

Machinery Noise. The on-the-job exposure to machinery noise probably affects more people for longer periods of time, than all other sources of noise.

To date, modifying existing equipment to respond to near term occupational safety requirements and hearing conservation programs has been the principal effort. While such activity has led to significant noise reductions for a few isolated pieces of specialized equipment, reduced levels are still excessive, particularly in the mining and industrial environment.

Currently, however, EPA is participating in a number of joint agency projects underway at federal facilities. These focus on machinery noise abatement in industrial environments (with the U.S. Navy Naval Sea Systems Command), and measures to reduce noise exposure in an electical power generating plant (with the Tennessee Valley Authority).

EPA is also taking part in inter-agency efforts to investigate methods for reducing construction site noise from construction equipment (with the U.S. Army's Construction Engineering Research Laboratory and the Federal Highway Administration).

The results of these efforts will be utilized in preparation of a construction site noise control handbook to assist federal, state, and local agencies in their efforts to ameliorate noise problems arising from public or private construction activity.

To help identify future industrial machinery noise abatement research, we have established three basic study elements:

(1) Technology Assessment - to categorize and prioritize major noise problems of industrial machinery and/or processes, taking into consideration such criteria as usage commonality across industry lines and severity of worker exposure

(2) Health and Welfare Assessment - to develop model(s) for quantifying the impacts of industrial equipment noise to determine exposure levels, hearing loss potential, communication interference for workers, and other risks in high noise workplace environments

(3) Economic Assessment - to assess the costs involved in quieting equipment to various levels for the industry, or industries, identified in the technology assessment element of the program.

Program results will be useful to OSHA, NIOSH and all others involved in the serious problem of industrial machinery noise.

Finally, noise reduction in the home is the subject of a joint EPA program with DOE, HUD, and NBS. The program will determine the compatibilty of energy conservation and noise reduction in home construction and evaluate low-noise interior environments which use quiet appliances and quiet heating and ventilating equipment.

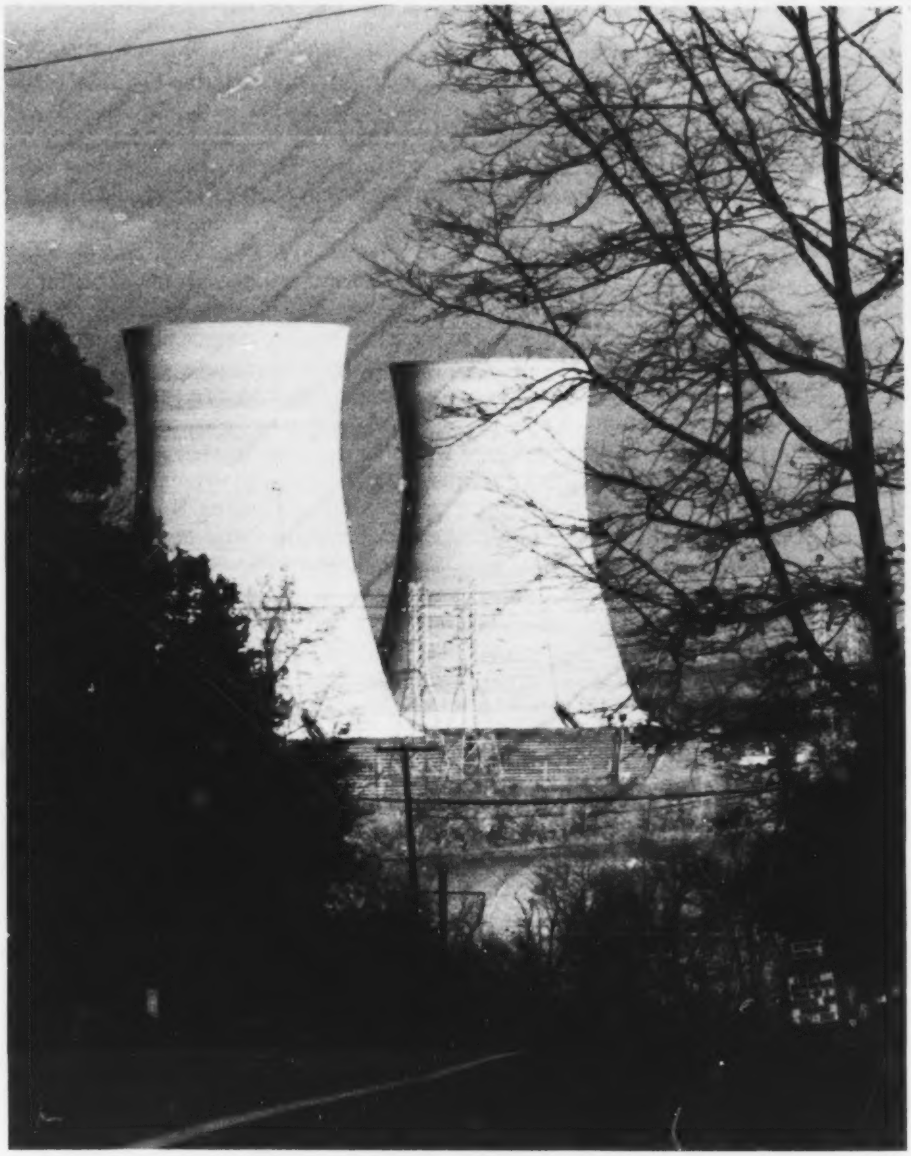
NOISE RESEARCH PLAN

PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
Noise induced hearing loss	Longitudinal study on children **A1**		continuing →		
		Complete temporary shift study in children **A1**			
	Incidence of hearing loss in U.S. population **A1**	continuing			
		Complete study of social handicap of noise induced hearing loss **A1**			
Non auditory physiological effects	Animal studies on cardiovascular disease **A2**		continuing →		
		Complete epidemiological feasibility sutdy **A2**	Complete retrospective epidemiological analysis **A2**		
		Human studies and clinical investigations (cardiovascular) **A2**	continuing →		
				Controlled epidemiological study **A2**	
Community response		Complete psychoacoustic study of engine brake noise **A3**	Complete study on short duration intusive noise **A3**	Complete study on construction site noise **A3**	
		Complete study on nighttime weighting penalty **A3**			
Sleep disturbance	Noise disturbed sleep health consequences (animal and human studies) **A4**			continuing →	

NOISE RESEARCH PLAN

PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
Control technology development		Engine technology assessment **B1**	Initiate heavy/medium duty truck testbed program **B5**	Install and evaluate modified engine in a heavy duty truck **B6**	
		Initially evaluate 4 quiet heavy duty trucks and 3 quiet medium duty trucks **B2**		Evaluate experimental quiet tire **B7**	
		Identify quiet tire/pavement characteristics **B3**			
		Develop and evaluate quiet production type tire and quiet pavement surface **B4**			

ENERGY AND ENVIRONMENT



America can achieve ample energy production and still maintain environmental quality. EPA's research supports these goals.

The spiraling cost of imported oil, the revolution in Iran and the gasoline lines in the summer of 1979 have intensified efforts to reduce national dependence on imported oil. The President has proposed a comprehensive and aggressive program to reduce this dependence and its deleterious effects on the nation's security and economy. The program emphasizes the use of domestic energy supplies, particularly coal, oil shale, unconventional natural gas and heavy oil, while encouraging energy conservation.

Assuming these conservation and production initiatives are successfully implemented, projections of U.S. energy resource requirements indicate a massive increase in both coal mining and utilization as well as major growth in the use of other fossil fuels. Coal mining in the United States is projected to increase from the current 700 million tons annually to 1.4 billion tons in 1990 and 1.9 billion tons in 2000. Although most of this growth is associated with conventional coal combustion, the production of synthetic liquids and gases from coal is expected to consume 120 million tons by 1990 and 300 million tons in 2000. To meet energy needs, the next few years will also probably see the birth of a major oil shale industry producing up to 400,000 barrels of oil per day in 1990 and 1.2 million barrels per day in 2000.

Energy resource trends are moving away from traditional sources.

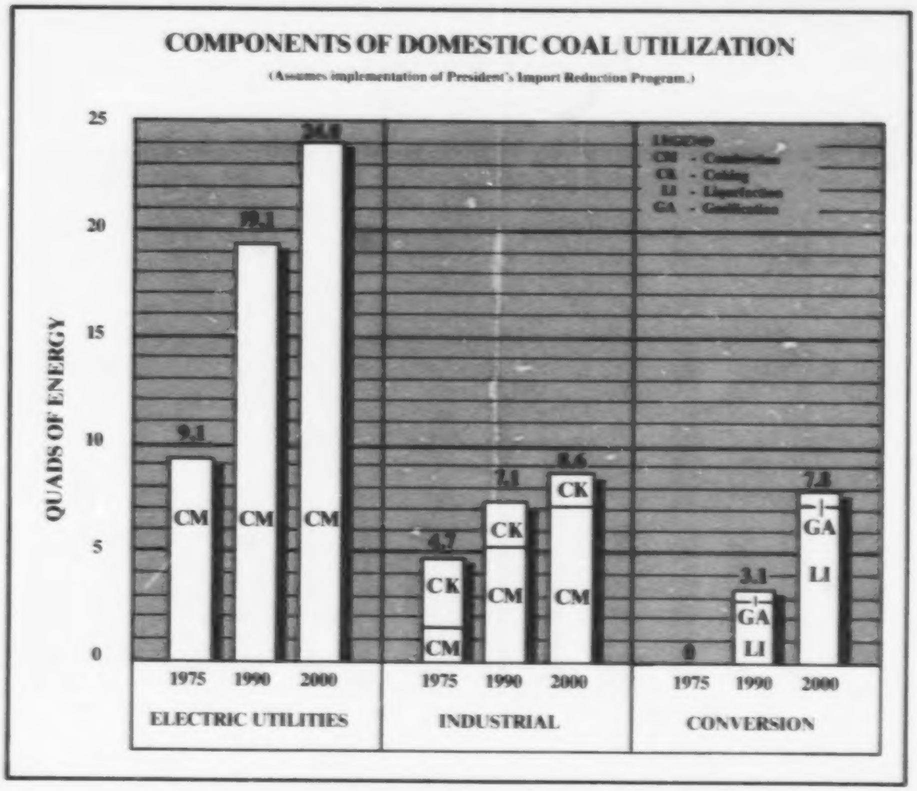
Energy resource trends are moving away from such traditional sources as on-shore oil and gas wells, and toward resources with higher environmental damage potential: coal (especially from western surface mining), oil shale, offshore oil and gas wells, unconventional natural gas and heavy oil. The trends also point to the increasing growth in the use of nuclear energy to generate electricity and indicate an increasing interest in the use of solar and geothermal energy sources.

With the increased use of the dirtier fossil fuels, a major threat to human health and environmental protection is posed. Problems could potentially emerge at each step in the fuel cycle—fuel extraction, processing and use. Increased coal and oil shale mining may, for example, increase erosion that subsequently creates a runoff that could contaminate surface waters. Or, the processing of coal and oil shale to produce synthetic fuels could result in the release of emissions and effluents contaminated with toxic materials. In any event, despite current regulations, increased coal combustion will result in the increased production of particulates, nitrogen oxides, sulfur oxides and solid wastes.

Major environmental legislation in the last decade has attempted to reduce environmental degradation caused by effluents and emissions from energy and industrial sources. New and existing energy facilities must all comply with portions of the Clean Air Act, the Clean Water Act, the Safe Drinking Water Act, and the Resource Conservation and Recovery Act. Generally this legislation mandates use of effective control technology to minimize air, water and land pollution. Our energy research program therefore complements and supplements our programs to deal with those forms of pollution (see also the chapters on Air, Water Quality, and Solid and Hazardous Waste).

Research Program

EPA's energy and environment research program is an interagency effort that will provide the information necessary to develop scientifically defensible policies that strike the all-important balance between ample domestic energy production, reasonable cost and environmental quality. To achieve this objective, our interagency program is split into two major areas of research effort. The first area is concerned with the health and environmental effects that stem from major current and emerging energy processes, while the second seeks to develop cost effective pollution control technology. Program emphasis over the next five years will be to generate information that supports establishment and implementation of technology-based and environmental guidelines and standards.

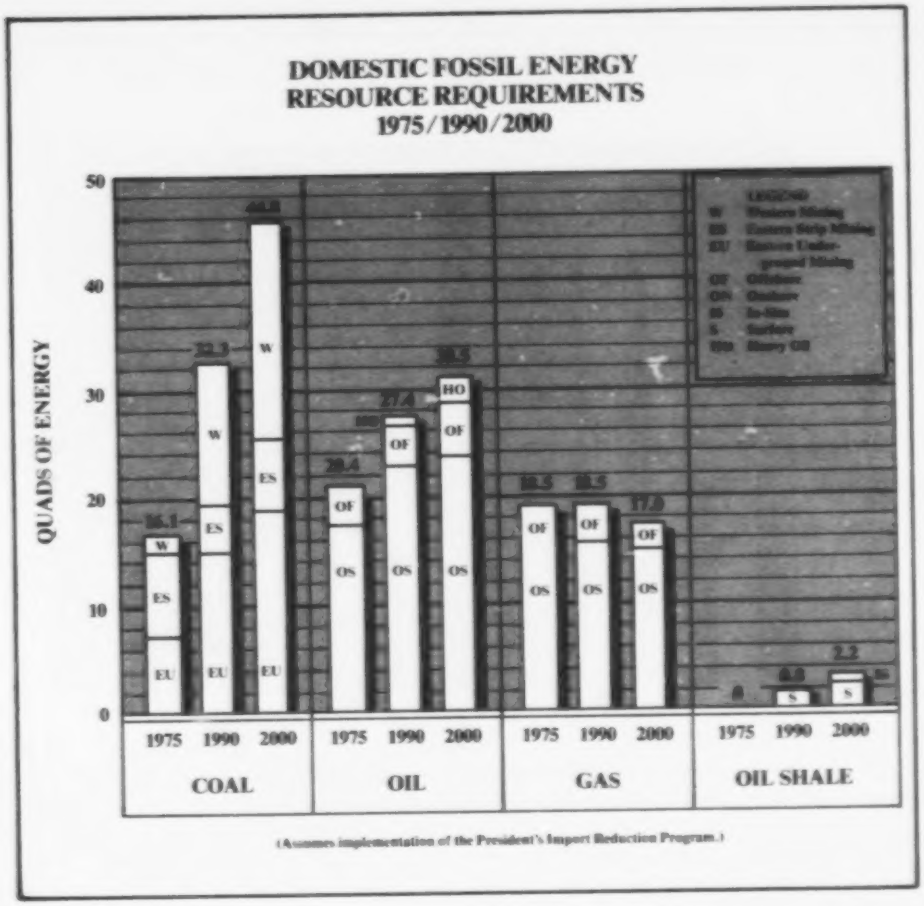


The overall design of the program allows for the generation of information to minimize environmental damage from energy systems, but management decisions must be made about which of those systems receives study priority. We have chosen to focus primarily on the current and projected coal fuel cycle as well as the oil shale cycle. Uranium and off-shore oil and gas extraction operations will also be studied but to a more limited extent.

The decision to structure our program in this fashion was based upon the consideration that coal and oil shale use over the next fifteen years will probably grow faster than the use of other fuel sources with coal expected to be the dominant fuel employed for electricity production. Coal will also grow in importance as a feed stock for synthetic liquids and gases. In addition, coal and oil shale both demonstrate the potential for creating major environmental problems throughout the fuel cycle.

Health and Environmental Effects Program

The energy health and ecological program is an interagency effort under EPA's direction that seeks to clearly define energy-related health and environmental problems and make them the subject of individual or cooperative research efforts. The agencies participating in the program and performing research are, in addition to EPA, the Department of Energy, the Department of Agriculture, the Department of the Interior, National Oceanic and Atmospheric Administration, National Aeronautics and Space Administra-



DOMESTIC FOSSIL ENERGY
RESOURCE REQUIREMENTS
1975/1990/2000

(Assumes implementation of the President's Import Reduction Program.)

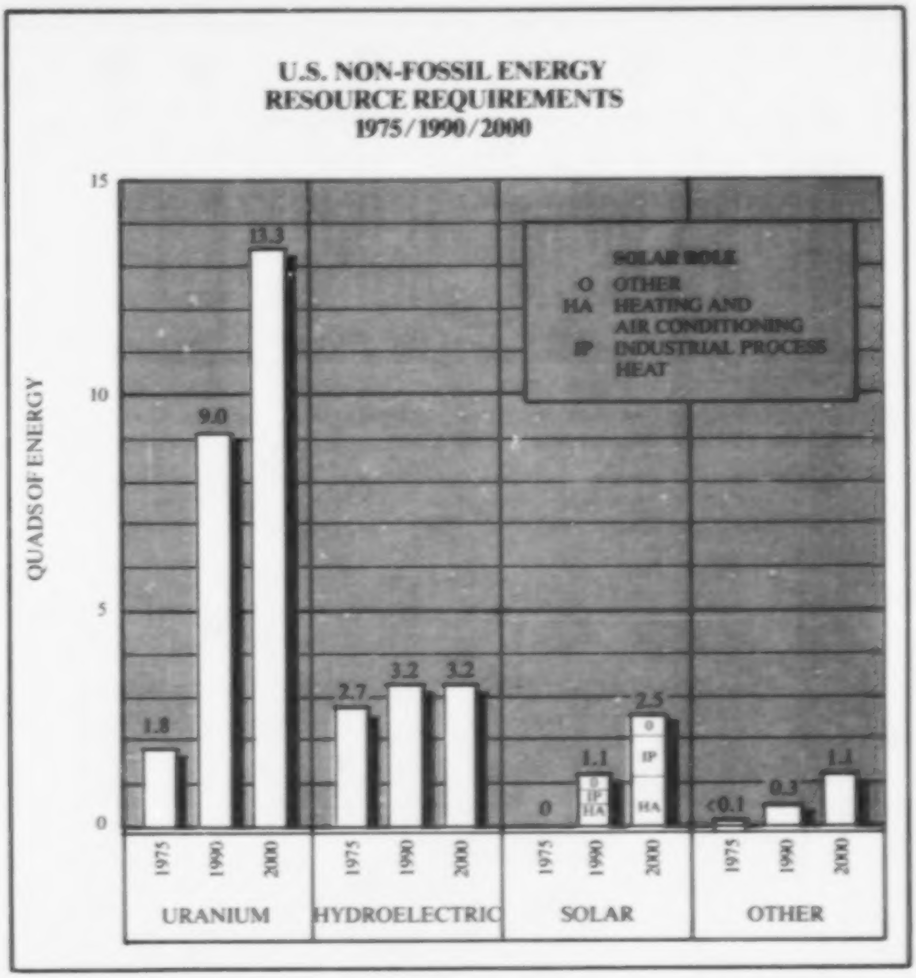
tion, National Bureau of Standards, National Institute of Occupational Safety and Health, National Institute of Environmental Health Sciences, and the Tennessee Valley Authority.

Health Effects

This program seeks to identify and improve estimates of health impacts from non-nuclear energy-related pollutants. While some of these impacts are direct, others may be very subtle and insidious. In this latter group, relating specific health effects to specific causes can be particularly difficult. Thus, the research performed in the program seeks to develop and validate the tools, the techniques and the models necessary to first accurately identify energy-related pollutants and their combinations which are health hazards, and then examine the basic mechanisms involved as the pollutant interacts with the body to produce its effect. (A3, A4, A5, A6)

The health effects problems will be studied by individual agencies or by interagency teams. The agencies participating in the energy/health programs are EPA, DOE, NIEHS, and NIOSH.

Air Pollutants Resulting from Combustion of Fossil Fuels. Criteria pollutants are those for which health- and environmental-based ambient standards have been set. All of these pollutants are generated in significant quantities by the combustion of fossil fuels. They include sulfur oxides, nitrogen oxides, suspended particulates, nonmethane hyd-



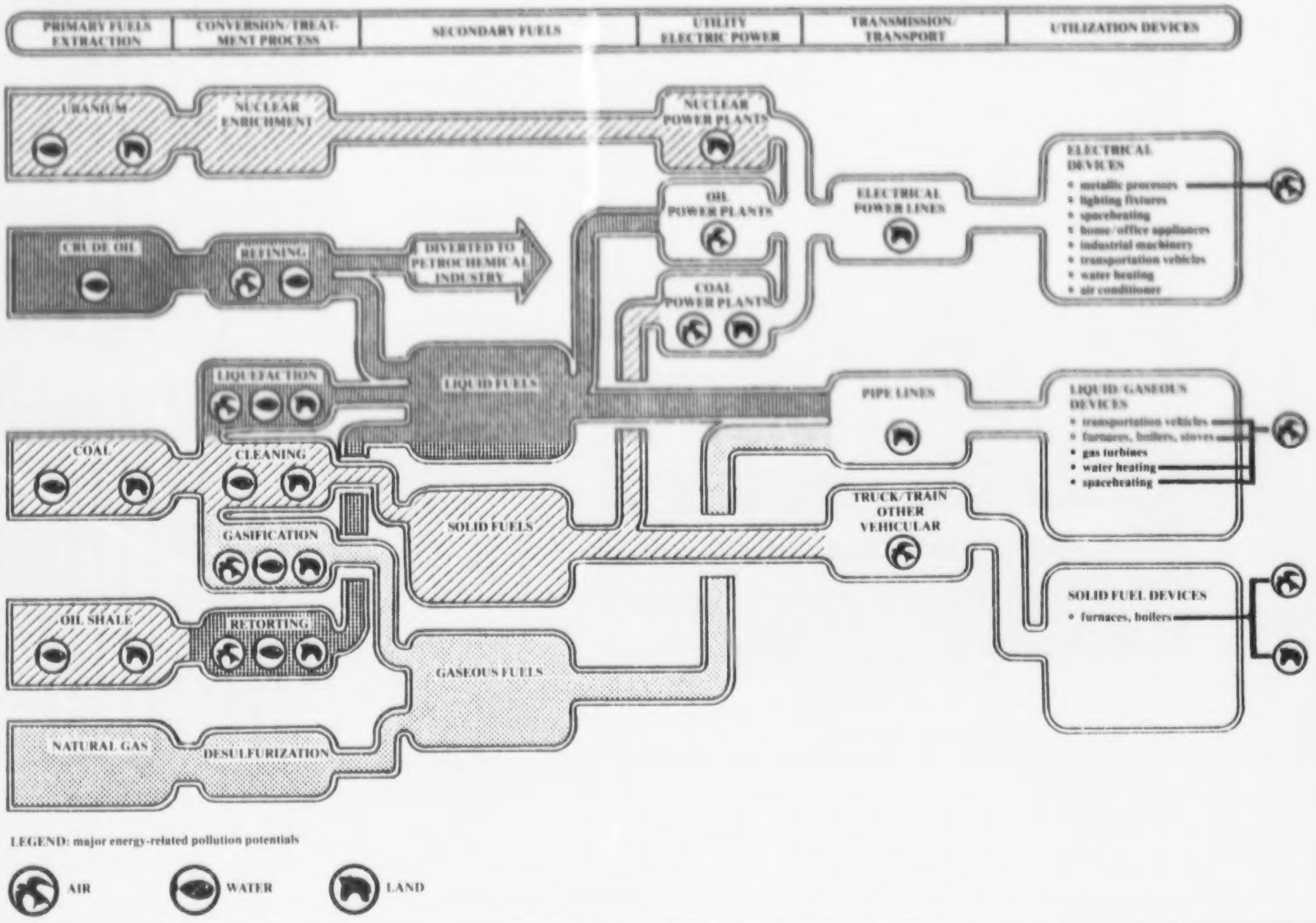
U.S. NON-FOSSIL ENERGY RESOURCE REQUIREMENTS 1975/1990/2000

rocarbons, carbon monoxide, and lead. A great deal of information has been generated describing the health effects of these substances; however, our knowledge and understanding in this area is constantly expanding, and as the effects of these pollutants become more clearly defined, emission and/or ambient standards are revised accordingly.

Noncriteria pollutants are those for which ambient standards have not been generated, and include many substances known to have deleterious health effects, such as sulfuric acid, nitric acid, nitrates, metallic oxides, other organic and inorganic species — and more hazardous air pollutants such as heavy trace metals (except lead), asbestos, cadmium, vinyl chloride, and benzene.

The health impacts of these pollutants range from slight to severe depending on the level of exposure, the pollutant, the susceptibility of the individual, etc. Such impacts may be restricted to the present generation, with damage ranging from temporary, reversible alterations of physiological function, to acute organ dysfunction, and to the induction of cancer. Pollutant agents can also affect the unborn generation, either directly by action on the developing fetus or indirectly by

SIMPLIFIED U.S. DOMESTIC FUEL FLOW: 1990


PRIMARY FUELS EXTRACTION
CONVERSION/TREATMENT PROCESS
SECONDARY FUELS
UTILITY ELECTRIC POWER
TRANSMISSION/TRANSPORT
UTILIZATION DEVICES
URANIUM
NUCLEAR ENRICHMENT
NUCLEAR POWER PLANTS
CRUDE OIL
REFINING
DIVERTED TO PETROCHEMICAL INDUSTRY
OIL POWER PLANTS
COAL POWER PLANTS
ELECTRICAL POWER LINES
ELECTRICAL DEVICES
• metallic processes
• lighting fixtures
• spaceheating
• home/office appliances
• industrial machinery
• transportation vehicles
• water heating
• air conditioner
LIQUEFACTION
LIQUID FUELS
PIPE LINES
LIQUID/GASEOUS DEVICES
• transportation vehicles
• furnaces, boilers, stoves
• gas turbines
• water heating
• spaceheating
COAL
CLEANING
GASIFICATION
SOLID FUELS
TRUCK/TRAIN OTHER VEHICULAR
SOLID FUEL DEVICES
• furnaces, boilers
OIL SHALE
RETORTING
GASEOUS FUELS
NATURAL GAS
DESULFURIZATION
LEGEND: major energy-related pollution potentials
AIR
WATER
LAND

damaging the germ cells of the prospective parents, the ultimate manifestation being genetic damage, resulting in malformations, dysfunctions, behavioral disorders, mental retardation, or cancer. (A1, A2)

Current research to preclude such impacts includes a major effort that involves the development and validation of biological screening tests that can quickly, accurately, and economically identify potentially hazardous compounds or agents. (A3, A4, A5) Evaluation tests are also being developed for use when a screening test indicates that an agent is biologically active. Ideally, these evaluation tests will be useful not only to expand screening test information, but will also facilitate human risk assessment for the agent in question. (A2)

Additional health impact research involves clinical studies to determine, under controlled conditions, the functional effects of the less noxious pollutants. (A1, A2) Making use of volunteer subjects, such studies also serve to identify susceptible subgroups. Another phase of the effort involves epidemiological studies to ascertain the impacts of pollutants on human health in high population density areas where air quality standards are sometimes exceeded. (A1, A2) These clinical and epidemiological studies, in addition to animal inhalation toxicology studies, will provide the scientific evidence necessary to set meaningful and legally defensible air quality standards.

Fossil Fuel Leachate Hazards. Waterborne pollutants from non-nuclear energy sources are found in effluents from fossil fuel cycle processes (including mining/drilling), transportation, storage, and in leachates from residues such as mine tailing, control systems sludges and spent oil shale. Research in this area includes conducting epidemiological studies of populations exposed to drinking water contaminated by fossil fuel processes, and developing techniques for toxic samples procurement from leachates for use in animal toxicology studies. (A7, A8, A9) In addition, bioassay screens and predictor tests are being developed and validated for use in identifying hazardous substances in aqueous waste streams. (A3, A6)

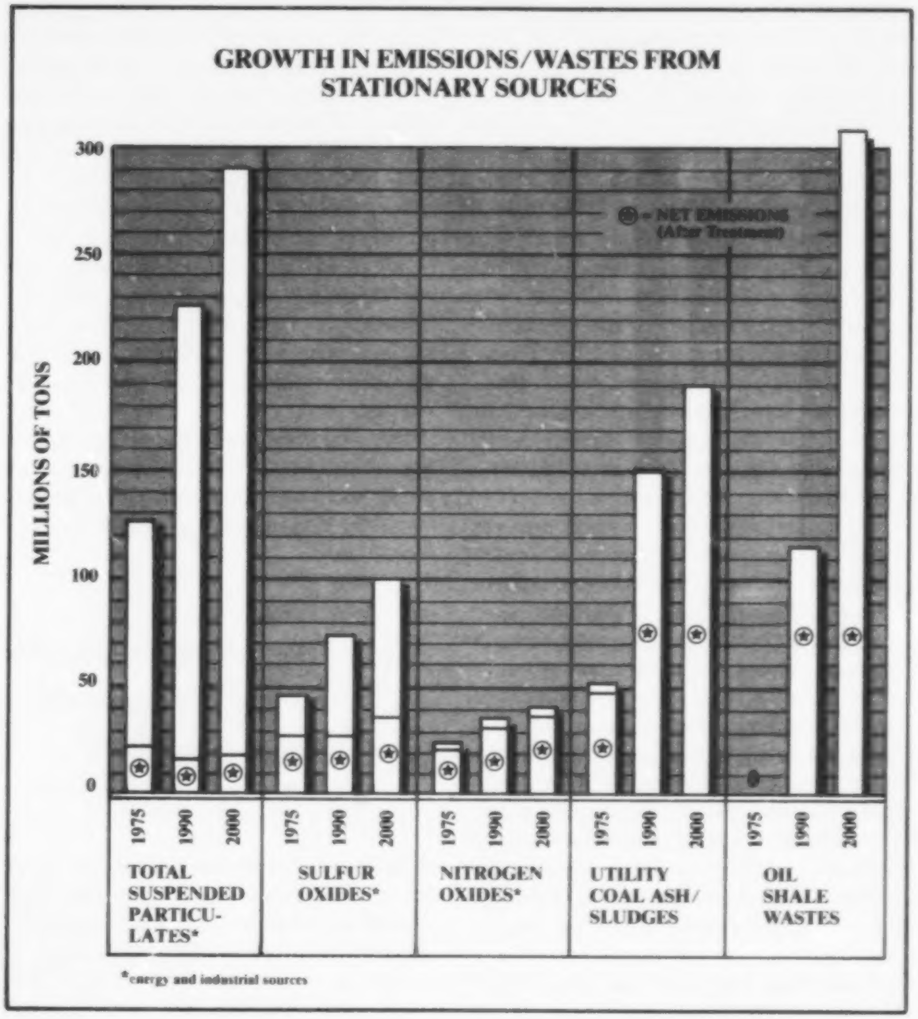
Advanced Fuel Combustion Processes and Synthetic Fuels. Advanced fossil fuel processes are potential generators of products and residuals which may be extremely hazardous to human health. The fluidized bed combustion of coal for example, generates an organic-coated fly ash that is different in geometry from that produced by conventional coal combustion. A study that assesses the relative health risks of these two combustion processes is currently underway. (A10) Synthetic fuel technologies such as oil shale processing, coal gasification, and coal liquefaction generate products and byproducts which without adequate controls can yield significant quantities of toxic substances.

Our immediate research concern is for the health of workers in these advanced fossil fuel and synthetic fuels industries. The program is currently conducting industrial hygiene studies to detect and identify pollutants in the workplace, while placing workers under close medical surveillance. (A11, A12) In addition, prospective epidemiological studies will be carried out, to consider such biological end points as dysfunctions of the reproductive, pulmonary, and nervous systems, as well as cancer of the skin, liver and lung. (A12) Also planned are animal toxicological studies of new products and residuals.

The program is currently conducting industrial hygiene studies.

Environmental Effects

Offshore Drilling. Oil and gas drilling and other energy related activities are increasing in estuarine and offshore environments. EPA has the legislative mandate in Section 402 of the Clean Water Act of 1977 to issue National Pollution Discharge Elimination System (NPDES) permits for discharges. However, not enough information on technical conditions exists. Thus, data on application factors, bioaccumulation, and Maximum Allowable



GROWTH IN EMISSIONS/WASTES FROM STATIONARY SOURCES

*energy and industrial sources

Toxicant Concentration (MATC) will be derived in order to assess the ecological hazards of oil spills, drilling fluids, drilling muds, drill cuttings, deck drainage, produced water, biocides, vented gas, and packer fluids discharged from offshore and estuarine oil and gas drilling operations. (B1, B2, B3)

Mine Reclamation. Management practices are needed to protect and maintain top soil returned to arid and semi-arid areas of western coal mining regions which have been surface-mined. This phase of the program will provide: (1) practices to prevent and control erosion; (2) methods to control the movement of water in reclaimed areas; and (3) means to improve or maintain the quality of water moving from mined areas into watercourses. (B4, B5, B9) The use of organic and inorganic waste materials such as fluidized bed wastes and municipal wastewater sludge for revegetation will be studied. Food crops and other vegetation grown during reclamation and revegetation will be evaluated for use by livestock and wildlife. (B8) Optimum control and use of precipitation, and the long-term impacts of various post-mining land uses will also be considered in the development of plant covers necessary to reclaim surface-mined lands in the West. (B6) Research will continue with an existing extensive effort by the USDA.

Technology is also needed for the reclamation of areas disturbed by uranium exploration and for hazardous tailings from past uranium mining. (B7) Research will provide regulatory guidelines for uranium mining, from exploration to the final disposal of the tailings.

Evaluation of Energy Related Toxic Substances. The biological effects of energy-related pollutants that are transferred to the sediment layers of water masses will be studied along with the impacts those pollutants have on invertebrate trophic levels of food chains. (B11) Changes involving the behavior of animal communities as a result of these pollutants will also be examined. (B11)

Research will continue with an existing extensive effort by the USDA.

The long-term consequences of such effects must be understood to evaluate and predict the pollutant's potential damage to living systems. Required is an adequate information base with qualitative and quantitative data on the structures and concentrations of the primary contaminants, to include petroleum hydrocarbons found in living organisms. (B10 through B16)

Pollutant Deposition on Ecosystems. Field and laboratory research will provide technical information for the use and protection of forestry, agricultural, and recreational resources. The environmental impacts of conventional gaseous air pollutants (i.e. SO_2, NO_x, O_3) and the wet and dry deposition of materials will be studied and evaluated. Specific areas of research include an assessment of atmospheric deposition effects on fish, wildlife, and their habitats, an evaluation of those areas in Minnesota and Wisconsin sensitive to acid precipitation and the integrated activities pertaining to the agronomic impacts of atmospheric pollutants. (B17 through B22)

Synthetic Fuels. Research will be initiated to develop a data base related to the environmental effects associated with synthetic fuels and advanced energy technologies. Activities will focus on the impacts of coal gasification/oil shale development and other energy technologies on aquatic systems, and the impacts of atmospheric emissions from new energy technologies on components of terrestrial ecosystems. Guidelines will be developed to mitigate the environmental effects associated with the accelerated extraction of coal and oil shale. (B23 through B28)

Atmospheric Transport and Effects

Energy related atmospheric effects are described in greater detail in chapter 4, "Air." The Interagency Energy/Environment Research Program focuses on the following research subjects:

Transport and Dispersion of Power Plant Stack Plumes at Short range. For an existing or planned fossil-fueld power plant in flat terrain, it is relatively straightforward to estimate gaseous and particulate pollution concentrations a short distance from the stack. Various models for that purpose provide reasonable predictions of annual, seasonal, daily and hourly mean concentrations of SO_2, NO/NO_2 and total suspended particulates (TSP). Difficulties arise when a plant is, or will be, located in complex terrain, such as a river valley, a plateau surrounded by a ridge, or at a land/sea interface. In such cases model predictions of mean or instantaneous pollutant concentrations may be off by as much as an order of magnitude.

A three year effort will be initiated to develop a functional model for power plant dispersion in complex terrain. Research will include measurements of the impacts that topographic obstacles such as mountains or ridges have on plumes and the plume dynamics and dispersion studies over com-

AIR, WATER AND SOLID WASTE ENVIRONMENTAL LAWS IMPACTING FOSSIL ENERGY FACILITIES

RELEVANT AUTHORITY	IMPACT
Clean Air Act Amendments of 1977	
● Set New Source Performance Standards (NSPS) for energy industries (Section 111).	● NSPS set for fossil utility boilers; industrial boiler NSPS being developed; oil shale, coal gasification, and liquefaction in planning stage.
● Set National Emission Standards for Hazardous Air Pollutants (NESHAP) for selected industries (Section 112).	● NESHAP requirements for synthetic fuels industry being evaluated as process plans become firm.
● Implement Prevention of Significant Deterioration (PSD) Program (Section 160).	● PSD permits required for all New Sources (coal-fired boilers and synthetic fuels plants) to prevent increases in particulate and SO_2 levels in areas having good air quality.
● Achieve Ambient Air Quality Standards (Section 109).	● Require utilization of appropriate control technology to reduce emissions to levels required to meet State Implementation Plan (SIP) goals.
● Set Lowest Achievable Emission Rates (LAER) (Section 171).	● Require level of pollution control technology greater than that which would normally be required by SIP for plant siting in non-attaiment areas.
Federal Water Pollution Control Act Amendments of 1977	
● Set discharge limits based on best conventional technology for energy industries (Section 306).	● Effluent guidelines for steam-electric industry issued, industrial boilers must meet guidelines for specific industry; effluent guidelines being planned for oil shale and coal gasification and liquefaction facilities.
● Set discharge limits based on best available technology for toxic pollutants (Section 307).	● For designated toxic pollutants best available control technology will be required, and will have greatest impact on the design of synfuel plants.
● Issue and enforce discharge permits to achieve above limits and to meet water quality standards (Section 402).	● Permits for electric utility plants and other industries being issued based on effluent guidelines; permits for synthetic fuels plants will be issued on basis of best information available until guidelines are issued.
Safe Drinking Water Act of 1974	
● Review projects for possible danger to underground drinking water supplies (Section 1424).	● All projects receiving federal assistance will be reviewed for processes impact on groundwater quality as it may impact drinking water.
Resource Conservation and Recovery Act of 1976	
● Set criteria for defining hazardous waste (Section 3001).	● Proposed procedures for determining if wastes are hazardous have been issued.
● Define acceptable disposal practices for hazardous wastes (section 3008).	● Utility wastes and spent oil shale classified as "special" wastes; if hazardous, they must meet monitoring requirements but not disposal requirements; best economically attainable disposable technology will be defined.
● Set guidelines for non-hazardous waste disposal (Section 4004).	● Disposal guidelines for non-hazardous utility waste will be completed in 1981, other energy wastes subject to state guidelines.

plex terrains. (C1, C2, C3, C4) This should provide EPA's Office of Air Quality Planning and Standards with a practical, flexible, tool to determine criteria pollutant dispersion in a variety of locations.

Transport, Transformation and Dispersion of Energy Pollutants At Long Range. Under certain conditions, power plants and other industrial sources can affect the air quality on a regional scale, i.e., up to a 1,000 km radius and beyond. Effects such as persistent regional pollution episodes, visibility impairing haze, and acid rain are all consequences of long-range transport and transformation of primary pollutant emissions. At present, we cannot predict the air pollution impact of single or aggregate power plants on a regional scale. Research, therefore, will assess various existing models for their suitability and their accuracy in predicting the impact of a single or a cluster of power plants on the air quality within a 100-1,000 km radius. (C5) This effort will be augmented by the development of a new generation of computer models capable of predicting air quality on a regional scale. (C6, C7, C8) Data from past and future field experiments will be used for model validation; major field validation studies will occur in FY82. (C8)

At present, we cannot predict the air pollution impact of single or aggregate power plants on a regional scale.

Acid Deposition. Acid deposition, also known as acid rain, may be one of the most significant environmental problems of the coming decade. It already poses an environmental threat to our forest, agricultural, and aquatic resources, a threat that could intensify with full scale development of our fossil fuel resources. The objective of our research program is to develop information on acid deposition which will assure that the nation's energy needs are met without sacrificing environmental quality. (C5, C6, C7, C8) Our acid rain research is discussed in detail in chapter 4.

Visibility Impairing Haze. Gaseous emissions from power plants, industries, and urban areas can be transformed into fine particulates (aerosols) which, in a certain size range, are effective scatterers of sunlight. High concentrations of such aerosols are the cause of hazy conditions that occasionally blanket large regions of the continent, notably the northeastern United States. In addition, single, large, coal-fired power plants may cause what is referred to as "plume blight," a phenomenon paticularly noticeable in the western United States that occurs when certain gaseous pollutants are converted into aerosols far downwind from the stack. Plume blight has been known to obscure some of the nation's most scenic areas including the Grand Canyon, Mesa Verde National Park and others.

The prevalent particulates that impair visibility seem to be ammonium sulfates, and secondary pollutants, that are transported long distances. The chemical, kinetic and dynamic processes involved with changing stack emissions to visibility-impairing haze are poorly understood at present. (C9, C10, C11) Research into the haze problem is further discussed in chapter 4.

Synfuel Atmospheric Pollution. Because large scale synfuel plants are not yet in operation in the United States, our research program must concentrate on monitoring and measuring synfuel air pollution effects at existing pilot and demonstration plants, in simulated laboratory and photochemical chamber experiments, and possibly at foreign synfuel operations. (C12, C13)

The expected atmospheric emissions from synfuel operations can be divided into two categories: those criteria pollutants (SO_x, NO_x, CO, TSP) from conventional boilers that provide the energy and steam for synfuel plants, and those non-criteria pollutants from leaks, vents and accidental releases from the actual synfuel process. The latter category of pollutants is expected to be composed of volatile and non-volatile organic and carbonaceous matter. The organic emissions from synfuel operation will probably pose the greatest health and ecological hazard.

Specific research projects to be performed are:

- Apply models for pollutant transport and dispersion at short range (0-10 km) to predict ambient mean concentrations of benzene, polyaromatics, mercaptans, thiophenes and other potential organic volatile pollutants from synfuel operations. Use foreign commercial plant source emission data, and/or pilot plant emission inventory. (C13)
- Apply models for pollutant transport, transformation and dispersion at long-range (0-1,000 km) to predict the formation of secondary reaction products, such as inhalable fine organic particulates. (C13)
- Accelerate laboratory and "smog chamber" investigations on photochemical transformation rates of organic pollutants anticipated to be emitted from synfuel operations. (C12)

Control Technology Program

This program is divided into three major categories: solid fuel extraction, conventional combustion, and fuel conversion.

Solid Fuel Extraction. Increased coal use in the next twenty years is expected to accelerate surface mining in the west as well as underground mining in the east. Coal extraction research will focus on defining pollution sources from active mines, and on the development and the demonstration of methods to control, treat and abate pollutants from mining and beneficiation processes. (D1 through D5, D7, D8, D16) Environmental control information that is compiled will be supplied to regulatory and control agencies, as well as to the mining industry. The bulk of this research effort will be directed at surface mining in the West where huge energy growth is projected, and where a lack of adequate environmental data and the fragile nature of ecosystems in such arid regions, make the West a prime area of concern. (D5)

The projected rapid growth of uranium mining may lead to surface and groundwater contamination, fugitive dust emissions, and problems of solid waste disposal. Current technology to control these problems is not adequate to fully protect human health and the environment. State-of-the-art control technology used in other mining activities will be evaluated for possible transfer or adaptation to uranium mine problems. (D16) Environmental control procedures will be studied for active uranium mining operations as well as for large abandoned open pit mines. (D16) If sufficient manpower and budget resources are available in the future, control procedures for the mines will be developed. We will also attempt to develop new or improved methods to reduce radiation from the mining and milling of uranium ores.

> The bulk of this research effort will be directed at surface mining in the West.

Because we expect large scale shale extraction as part of future oil shale industries, our research will evaluate control technology and techniques that can protect surface and subsurface water from the effects of runoff caused by extraction and spent shale disposal. (D6, D9 through D15, D17, D19)

Conventional Combustion. Conventional combustion will continue to be the prime method to utilize coal well into the twenty-first century, despite the growth of a major coal-based synfuel industry. The National Energy Act of 1978 mandates conversion of many utility and industrial power facilities from oil and gas to coal, and prohibits all new oil or gas utility boilers. The President has proposed additional legislation to promote the early retirement of existing oil-fired power plants by 1990. Evolving energy policies are clearly emphasizing an increased reliance on coal for electricity and steam generation. This nationwide movement to increased coal underlines the need for the development of economical and effective control technology for pollutants generated during coal combustion. The main pollutants are sulfur oxides, nitrogen oxides, particulates and associated solid wastes of fly ash and sulfur sludge. The primary objective of our research is to develop and demonstrate cost effective control technology to be used in conjunction with utility and industrial processes to render them less environmentally damaging.

Sulfur Oxide. A major environmental goal is the control of sulfur oxide emissions from coal combustion at utility and industrial facilities. Projected coal combustion increases over the next twenty years will tend to neutralize air quality gains that might have otherwise accrued as a result of current sulfur oxide regulations, including the recently promulgated New Source Perfomance Standards for utility boilers. Sulfur oxides are the precursors to the formation of sulfate particulates which have been implicated as the major contributors to the increased acidity of precipitation (see chapter 4, "Air").

EPA and DOE are cooperating to upgrade flue gas desulfurization techniques (FGD)—currently the only sulfur control technology capable of general application in the next ten years. Estimates are that by 1990, electrical utilities will have invested between $10 and $20 billion for the construction and operation of FGD units.

Although some commercial FGD installations are now performing reliably and effectively in the United States and abroad, major technological improvements are possible through application of research, development and demonstration. Overall, program research goals include: higher reliability and performance (E1) of lime and limestone scrubber systems, demonstration of environmentally acceptable sludge disposal practices, and low system cost. (E5) To help meet these goals and to provide support for regulatory and enforcement activities, EPA will work closely with utilities and industries to: (1) develop and evaluate low cost dry scrubbing systems as an alternative to wet scrubbing, (2) demonstrate organic additives as an adjunct to limestone scrubbing in order to improve SO_2 removal performance and to lower costs, and (3) define acceptable sulfur sludge disposal practices. (E1 through E5)

Nitrogen Oxides. Recent studies have projected a steady growth in annual NO_x emissions, and by the year 2000, it is expected nitrogen oxide emissions will double. Significant increases in NO_x emissions and potentially stricter NO_2 ambient air standards such as those short term standards outlined in the 1977 amendments to the Clean Air Act could mean a manifold increase in Air Quality Control Regions designated nonattainment areas.

EPA has embarked on an aggressive NO_x control technology program to mitigate increased national NO_x emissions from increased direct coal combustion and the projected burning of coal- or shale-derived synthetic fuels. (E6 through E13) This program is focusing primarily on utility and industrial boilers that account for more than half of all today's stationary source NO_x emissions. (E9, E11, E12) The program for a low NO_x pulverized coal burner is designed to lower uncontrolled NO_x emissions by 85 percent. The low NO_x burner has achieved emission rates as low as 0.15 pounds of NO_x per million BTU as compared to current regulated emission rates of 0.5-0.6 pounds. The program will soon enter the prototype development stage and field demonstrations. (E8) Two industrial boilers and one utility boiler will be retrofitted with the low NO_x burner for an eighteen month demonstration program to be completed in 1983. (E9) Successful demonstration of this nitrogen oxide control technology could allow expanded use of coal and coal-derived fuels with only minimal environmental impacts.

EPA has embarked on an agressive NO_x control technology program.

Those combustion conditions conducive to low NO_x emissions are also conducive to SO_2 removal by limestone in the burner's flame zone. Thus, efforts are currently underway to define the applicability and economics of a simultaneous SO_2 and NO_x control technology that involves injecting a limestone-coal mixture into a low NO_x burner. (E6) Using the system, bench scale tests have demonstrated potential SO_2 emissions reductions of more than 80% for high sulfur coal. Current plans call for continued experimentation to determine conditions that could yield 90+% reductions in potential SO_2 emissions and to define the processes necessary and the costs involved in achieving a reduction of this level. If the program proves successful, preliminary economic studies indicate that substantial savings of SO_2 control costs could be realized.

Synthetic fuels are often high in nitrogen content and upon combustion can yield high NO_x emission rates. EPA research will define the conditions under which synthetic fuels can be burned in compliance with environmental regulations. (E13)

Particulates. Fine particulates are a health hazard because they can bypass the body's respiratory filters and penetrate directly into the lung. Fine particles in the atmosphere remain airborne for extended periods of time, obstruct light, and cause limited visibility or haze. Furthermore, toxic metals and hazardous compounds which tend to adsorb or condense on fine particles are often transported through the air by them. Ambient particles originate either as primary emissions, or may be secondary pollutants, transformed from gaseous emissions such as SO_2. Our research into the particle problem will develop economical particulate control technology for fossil fuel combustion and other industrial sources of directly-emitted particulates. Over the next five years this program will focus on the following objectives:

Synthetic fuels are often high in nitrogen content.

- Develop low cost control technology for fossil fuel combustion sources. Low sulfur coal combustion methods will be emphasized as post-combustion electrostatic precipitators and fabric filters are relatively expensive. Particular attention will be placed on particle prechargers which offer great potential cost savings. (E15, E17)
- Develop a data base for particle size distributions for energy and industrial sources. This effort will help EPA consider appropriate control strategies should it revise the current total suspended particulate standards or replace them with inhalable (fine) particulate standards. (E14)

Environmental Assessment. Regulatory attention to date has been focused primarily on conventional large volume air pollutants such as sulfur oxides, nitrogen oxides and particulates. However, conventional combustion of coal, wood and oil fuels also yields emissions of other materials such as polycyclical organic materials, heavy metals, and radionuclides that are potentially hazardous. The objective of the conventional combustion environmental assessment program is to identify, and quantify such emissions and to determine their potential health and ecological impacts. (E18) Where appropriate the effectiveness of conventional control technology will be evaluated.

Fuel Conversion—Synthetic Fuels. To support the nation's renewed interest in synthetic fuels as an alternative to imported oil, EPA is accelerating its program to evaluate and develop the controls needed for synfuel processes. (F1 through F18) The acceleration of this program is considered to be particularly important because incorporation of effective environmental controls at a formative stage can facilitate the synfuel plant permit and leasing process, while at the same time assuring immediate environmental protection. (F1, F2, F3, F5, F8, F11) The major synfuel processes near commercialization are direct and indirect coal liquefaction, coal gasification, and oil shale retorting. Pollutants resulting from these forms of coal and oil shale use generally differ from those associated with normal coal combustion. Synfuel processes, for example, generally result in far fewer emissions of conventional air pollutants such as sulfur oxide and

SYNTHETIC FUEL PROCESSES

COAL GASIFICATION

Status

High BTU gas: Lurgi technology utilizing gasification, purification and methanation is close to commercial. All major components proven; however, integration at commercial scale not yet accomplished and cleanup systems untried at commercial scale.

Medium/Low BTU gas: Technology is commercial with over 100 operating plants, most outside the U.S. However commercial experience lacking on gas and water cleanup.

Major Environmental Concerns

- Sulfur compound emissions
- Particulate and trace element emissions
- Organic emissions; particularly benzene, phenols and polycylic aromatics
- Contamination of surface and groundwaters from landfills and ponds
- Worker exposure to toxic and carcinogenic materials
- Subsidence and aquifier disruption (second generation in-situ gasification)

INDIRECT COAL LIQUEFACTION (Coal Gasified Then Catalytically Converted to Liquids)

Status

Two classes of processes are commercial: (1) methanol plants using any of five processes have been used in United States and are currently used overseas. Additional step allowing high octane gasoline production from methanol close to commercialization, (2) Fisher-Tropsch, which produces a variety of fuel products, is operating in South Africa.

Major Environmental Concerns

- Same as Coal Gasification Above.

DIRECT COAL LIQUEFACTION (Hydrogenation of Coal in Coal-Liquid)

Status

Several processes have been pilot tested including Solvent Refined Coal-II, Exxon Donor Solvent, H-Coal and Synthoil Processes require scale up to large pilot or demonstration plants scale before commercial plants can be built in late 1980's or early 1990's.

Major Environmental Concerns

- Sulfur compound emissions
- Particulate and trace element emissions
- Organic emissions; particularly benzene, phenols and polycyclical aromatics
- Contamination of surface and groundwaters by leaching from landfills and evaporation ponds
- Fuel product(s) toxicity

OIL SHALE PROCESSING

Status

Several above-ground and in-situ retorting processes have been evaluated at pilot scale and are near commercial: Union, Colony-Tosco and Occidental and Rio Blanco (in-situ) have all initiated projects for the production of oil from shale at or near commercial scale.

Major Environmental Concerns

- Sulfur emissions
- Particulate emissions
- Organic emissions; particularly high molecular weight compounds
- Environmentally acceptable disposal of spent shale
- Contamination of surface and groundwaters from evaporation ponds
- Worker exposure to toxic and carcinogenic materials
- Aquifier contamination from terminated retort (in-situ)

nitrogen oxide; however, the potential for emissions of high molecular weight organics and other toxic materials is greatly increased.

The EPA program will accelerate efforts to evaluate control technology for the major process streams of first and second generation synfuel processes. Research will evaluate both the performance and the cost of control technologies for the major coal liquefaction, gasification and oil shale processes. (F10, F18) Primary and secondary pollutants from the processes will be identified and quantities estimated; methods of pollution control will be identified and carefully evaluated. (F4, F6, F10, F18) Air, water and solid waste effluents will be studied from all process sources, including the conversion process, the environmental controls process and any ancillary processes such as oxygen production and steam generation. (F6, F10, F14, F18) This program is being carefully coordinated within EPA so that results can assist air, water and solid waste regulatory and enforcement offices to effectively perform their regulatory and permit duties.

The major near term research program outputs will be a series of Pollution Control Guidance Documents for the major synfuel processes. (F1, F2, F3, F5, F8) The documents, to be published in the next two years, will provide detailed environmental control guidance to synfuel developers and permitting authorities prior to promulgation of legally binding standards. Such guidelines are expected to expedite the permit process by defining best available control technology. Concurrent and subsequent research will support technology-based emissions/effluent standards to be set by EPA sometime after 1982. (F15)

ENERGY RESEARCH PLAN

PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
HEALTH EFFECTS					
Determine health effects of criteria and noncriteria pollutants from fossil fuel combustion (EPA, NIEHS)	Initiate a balanced program of epidemiological, clinical and toxicological studies to determine the impact of criteria and non-criteria pollutants emanating from fossil fuel combustion processes on the respiratory, cardiovascular and digestive systems. **A1**				Evaluate the relationship between risk to human health and energy-related pollutants **A2**
Develop and validate bioassy screens and predictor tests (EPA, NIEHS, National Laboratories)	Develop and validate sensitive, quantitative, reliable, and accurate techniques for identifying hazardous wastes and screening effluents and emissions from energy-related facilities. **A3**	Correlate results of short-term *in vitro* tests with *in vivo* chronic exposure tests for mixtures of energy-related pollutants. **A5**	Improve models for animal data interpretation and extrapolation. **A6**		
	Improve short-term test procedures and dosimetric techniques for evaluating body burdens of energy related hazardous materials **A4**				
Determine health hazards of fossil fuel leachates and specific energy-related pollutants (EPA, National Laboratories)	Initiate epidemiologic studies of populations exposed to drinking waters contaminated by leachates from fossil fuel cycle processes. **A7**				Provide information on the relationship between human health effects and water-borne, energy-related water pollutants. **A8**

PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
					Provide additional information on the synergistic effects of cadmium with other pollutants. **A9** Analyze human risk of fluidized bed combustion vs. conventional coal combustion. **A10**
Improvement of data base on health impacts fuel processes, products, and residuals (EPA, DOE, NIOSH)		Continue industrial hygiene and medical surveillance of occupational groups from the synfuel industry. **A11**		Continuing Activity	Provide initial exposure assessment of health effects on workers in the synthetic fuels industry **A12**
ECOLOGICAL EFFECTS					
Offshore drilling					
(Department of Commerce (NOAA), Department of the Interior, Department of Energy, Environmental Protection Agency)	Identify potential areas of environmental impact. Develop assessment methods for coastal and off-shore impacts. **B1**	Initiate on-site research in potential impact areas. **B2**	Continuing Activity		Prepare guidance documents for placement of drilling structures and develop management plans for drilling activities. **B3**

PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
Mine reclamation (Department of Agriculture, Environmental Protection Agency, Department of the Interior)					Develop and establish management practices for mined lands **B4** Develop practices to control errosion and maintain water quality. **B5** Develop new plant materials for the reclamation of arid and semi-arid areas. **B6** Identify reclamation practices for uranium mining so as to minimize fugitive dust problems. **B7** Investigate methods for culture of feed and food crops on coal-mined lands. **B8** Prepare user-manuals and handbooks for reclamation of surface mined lands and for monitoring potential impacts. **B9**

ENERGY RESEARCH PLAN

PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
Energy related toxic substances (Department of Commerce (NOAA), Department of Energy, Department of Health & Human Services (NIEHS), Tennessee Valley Authority, Environmental Protection Agency)		Evaluate toxicity of biocides from cooling towers, leachates from scrubber sludge and fly ash, and petroleum hydrocarbons. **B10**	Identify potential effects on trophic structure, behavior of aquatic organisms, and bioaccumulation impacts. **B11** Provide impact data for consent decree water pollutants. **B12** Develop test methods and evalutation procedures for determining environmental impacts of toxic pollutants **B13**	Provide screening techniques to determine impacts of toxic materials on the environment and transfers to human food sources. **B14**	Develop biomonitoring plans for evaluating energy technologies. **B15** Provide risk assessment data relevant to impacts of energy-related toxicants. **B16**
Atmospheric pollution impacts (Tennessee Valley Authority, Department of Energy, Department of the Interior, Environmental Protection Agency)	Initiate and continue research to determine the ecological and economic impacts of air pollutants from energy technologies. **B17**	Complete evaluation of impacts of pollutants from power plants of northern great plain ecosystems. **B18**		Provide guidance for compliance with Class I Air Quality Regulations. **B19**	Provide air quality assessment information relevant to economic impacts on agriculture natural systems. **B20** Develop models for assessing pollutant impacts on fish, wildlife, and their forest or aquatic habitats. **B21** Contribute to the national programs involving the environmental effects of acid precipitation and gaseous pollutants. **B22**
Synthetic fuels (Environmental Protection Agency, Tennessee Valley Authority, and other interagency organizations)	Plan water use/impact studies, air effects research. **B23**	Initiate projects for the development of conceptual models. **B24**		Evaluate the bio-impacts of enhanced oil and gas recovery methods, and the disposal of synfuel wastes. **B25** Develop conceptual models for synthetic fuels. **B26**	Develop impact strategies from available knowledge and initiate the evaluation of mitigation activities. **B27** Evaluate the impacts of coal gasification and oil shale technologies on aquatic environments. **B28**

PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
ATMOSPHERIC TRANSPORT AND EFFECTS					
Complex Terrain Model (EPA in cooperation with NOAA, EPRI).	Computerized model of criteria pollutant dispersion from variable height stacks in complex terrain. Initiate plume impactation study. **C1**	Complete plume impactation study. **C2** Initiate full scale plume study. **C3**		Deliver model and users guide. **C4**	
Regional modeling of energy pollutant dispersion and transformation. (EPA, DOE, TVA, NOAA in cooperation with EPRI)	Predict air quality impact from single or aggregate power plants on a regional scale, such as the Ohio Basin, the Northeast, or the western United States. Include modules for acid rain, visibility impairing haze, and hazardous fine particulates. Conduct workshop to assess state-of-the-art and define research gaps. **C5** Initiate model development. **C6**		Complete empirical models. **C7**		Refinement of models. **C8**
Visibility protection of federal Class I Areas. (EPA in cooperation with DOE, EPRI)	Identify sources and causes of anthropogenic haze which impairs visibility in our National Parks, and occasionally blankets the whole Eastern seaboard. Establish monitoring stations for visibility and visibility impairing aerosols. **C9**			Continue monitoring and model development for visibility impairing haze dispersion. **C10** Provide recommendations for visibility conserving strategies. **C11**	

ENERGY RESEARCH PLAN

PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
Synfuel atmospheric effects. (EPA, TVA, DOE)	Characterize emissions, and develop atmospheric transport, transformation and dispersion models for pollutants which may be emitted from boilers, leaks, vents and accidental releases of synfuel plants and oil shale operations. Plan approach through Interagency Committee. **C12**			Deliver synfuel dispersion models. **C13**	
CONTROL TECHNOLOGY					
Extraction	Complete interim study of surface mine sedimentation ponds. **D1** Complete preliminary assessment of Northern Great Plains coal mining area. **D2** Provide users manual on acid mine drainage rehabiliation. **D3**	Complete characterization and control technology assessment of solid wastes produced from non-coal mining activities. **D4** Complete assessment of impact of western coal development on surface and groundwater. **D5** Develop revegetation techniques for spent oil shale. **D6**	Complete revised technology requirements for water discharged from mining operations. **D7** Provide manual of methodology for controlling fugitive dust from surface mines. **D8** Evaluate effectiveness of oil spill regulations. **D9** Provide users manual for oil spill prevention. **D10**	Assess potential pollution problems from tertiary oil and gas recovery. **D11** Assess impact of oil shale disposal and develop appropriate control technology. **D12** Complete control technology guidance for offshore oil and gas production. **D13** Determine leaching characteristics of raw oil shale. **D14**	Complete design criteria for on-shore and off-shore pollution control equipment. **D15** Complete environmental assessment of uranium production and evaluate available control technology. **D16** Assess impact on groundwater of in-situ oil shale operations. **D17** Provide manual of techniques for removal and control of oil spilled on land and water. **D18** Provide users manual for oil spill control in cold climates. **D19**

PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
Sulfur Oxide Control		Complete full scale testing of adipic acid modified limestone wet scrubbing to increase scrubber reliability and lower cost. **E1** Initiate long term evaluation of the performance and reliability of a full scale utility boiler spray-dryer SO_2 control system. **E2**	Prepare SO_2 control technology assessment report to aid in the four year review of the standard of performance for utility boilers. **E3**	Prepare SO_2 control technology assessment report to be used in the four-year review of the standard of performance for industrial boilers. **E4**	Initiate the full scale testing of simultaneous limestone-coal injection into the low NO_x coal burner. **E5**
Nitrogen Oxide Control	Complete the demonstration of coal/limestone pellets as a low cost, simultaneous SO_x and NO_x control method. **E6**	Complete the evaluation of fuel efficient NO_x controls for stationary internal combustion engines. **E7**	Complete prototype scale research and development for a low NO_x emission, heavy oil burner which can be used in oil field steam generators. **E8**	Complete the demonstration of the low NO_x coal burner on two industrial boilers and one utility boiler. **E9** Complete the demonstration of dry NO_x control for small gas turbines using conventional fuels and synthetic oil. **E10** Prepare NO_x control technology assessment reports for the four year review of the standards of performance for utility boiler and gas turbines. **E11** Prepare NO_x control technology assessment report for the four year review of the standards of performance for industrial boilers and internal combustion engines. **E12**	Initiate the evaluation to determine the applicability of combustion modification concepts to synthetic, high nitrogen fuels so that these fuels can be used in compliance with existing regulations. **E13**

ENERGY RESEARCH PLAN

PROGRAM AREA	FISCAL YEAR 1980	FISCAL YEAR 1981	FISCAL YEAR 1982	FISCAL YEAR 1983	FISCAL YEAR 1984
Particulate Control		Characterize inhalable particulate matter emissions from priority point and non-point sources. **E14**	Preliminary full scale demonstration of electrostatically enhanced fabric filters as a means of increasing air to cloth ratio for utility baghouses. **E15**	Demonstration of the commercial viability of a pre-charger as a means of augmenting electrostatic precipitator performance of high resistivity fly ash. **E16**	Complete assessment of long term feasibility of using fabric filters on large scale utility boilers using low sulfur western coal. **E17**
Environmental Assessment				Characterize POM, heavy metal and readionuclide emissions from conventional combustion sources. **E18**	
SYNTHETIC FUELS	Complete PCGD[1] for leading oil shale in situ and surface retorting processes **F1** Complete PCGD for low BTU coal gasification based on Wellman-Galusha and Stopic processes **F2** Complete PCGD for indirect coal liquefaction processes based on Fischer-Tropsch, Mobil M Gasoline and coal-to-methanol processes **F3** Characterization of emissions/effluents from wide variety of coal gasification, coal liquefaction and oil shale retorting processes **F4**	Complete PCGD for high BTU coal gasification based on Lurgi process **F5** Pilot control technology evaluation of sulfur control at Occidental oil shale site **F6** Develop disposal/treatment techniques for spent shale **F7**	Complete PCGD for direct coal liquefaction based on SRC process **F8** Complete study of impacts resulting from handling of direct coal liquefaction products **F9** Complete study comparing near term synthetic fuels processess as to cost of control, efficiency and environmental impacts **F10** Support for the regions in permit application review **F11**	Revised PCGD completed for indirect coal liquefaction processes based on Koppers Totzek and Texaco front-end gasification processes **F12** Revised PCGD completed for low BTU coal gasification processes based on in situ coal gasification **F13** Assessment of carcinogenic impact of synthetic fuel processing **F14** Additional effluent/emission data provided for near term technologies in support of control technology based regulatory program **F15**	Revised PCGD for direct coal liquefaction processes based on SRC II and H-coal demonstrations **F16** Revised PCGD for oil shale processes based on in situ processes **F17** Complete study comparing first and second generation synthetic fuels processes as to cost of control, efficiency and environmental impact **F18**

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[1] PCGD—Pollution Control Guidance Document containing interim emission/effluent guidelines and suggested pollution control technology. The suggested EPA regulatory approach to the President's synthetic fuels initiative requires PCGD's for near term technologies by late 1980 at the time commercial synthetic fuels enter the design stage.

ANTICIPATING FUTURE ENVIRONMENTAL PROBLEMS

We must look ahead to identify trends which could adversely affect our environment. EPA's anticipatory research program is designed to do this.

Introduction

Our research program is designed to support EPA's regulatory activities and to look over the horizon to identify trends affecting our future environment. For the nation to avoid or effectively mitigate future problems, adequate information must be available to Agency research and development planners. ORD's 1978 establishment of the Anticipatory Research and Strategic Analysis programs was a major step to assure that such information would indeed be there when required.

The need to link EPA's anticipatory research with strategic planning is clear. Many, if not most, major environmental problems we face today were potentially discernable before they fully revealed themselves. Problems with pesticides, fertilizer runoff, hazardous wastes, and the air polluting emissions of mobile and stationary sources could have been foreseen.

Much of the stress on the environment can be directly attributed to increases in the national and global population. Compounding that stress, in many parts of the world, is increasing per capita consumption. Together or separately, these increases result in more resource exploitation, more energy use, more or larger industrial facilities, more by-products, and more waste.

Much of the stress on the environment can be directly attributed to increases in the national and global population.

With environmental stress as a by-product of people and their activities, population and economic growth trends are useful first order leading indicators of the environmental future.

In our program, we seek to look beyond these basic indicators; however, our goal is to first identify specific types of changes that may affect the future environment. Then we must identify and classify the future problems that may result from these changes so that proper exploratory research can be instigated.

Classes and Causes of Environmental Problems

To organize our research effort we divide environmental problems into five classes:

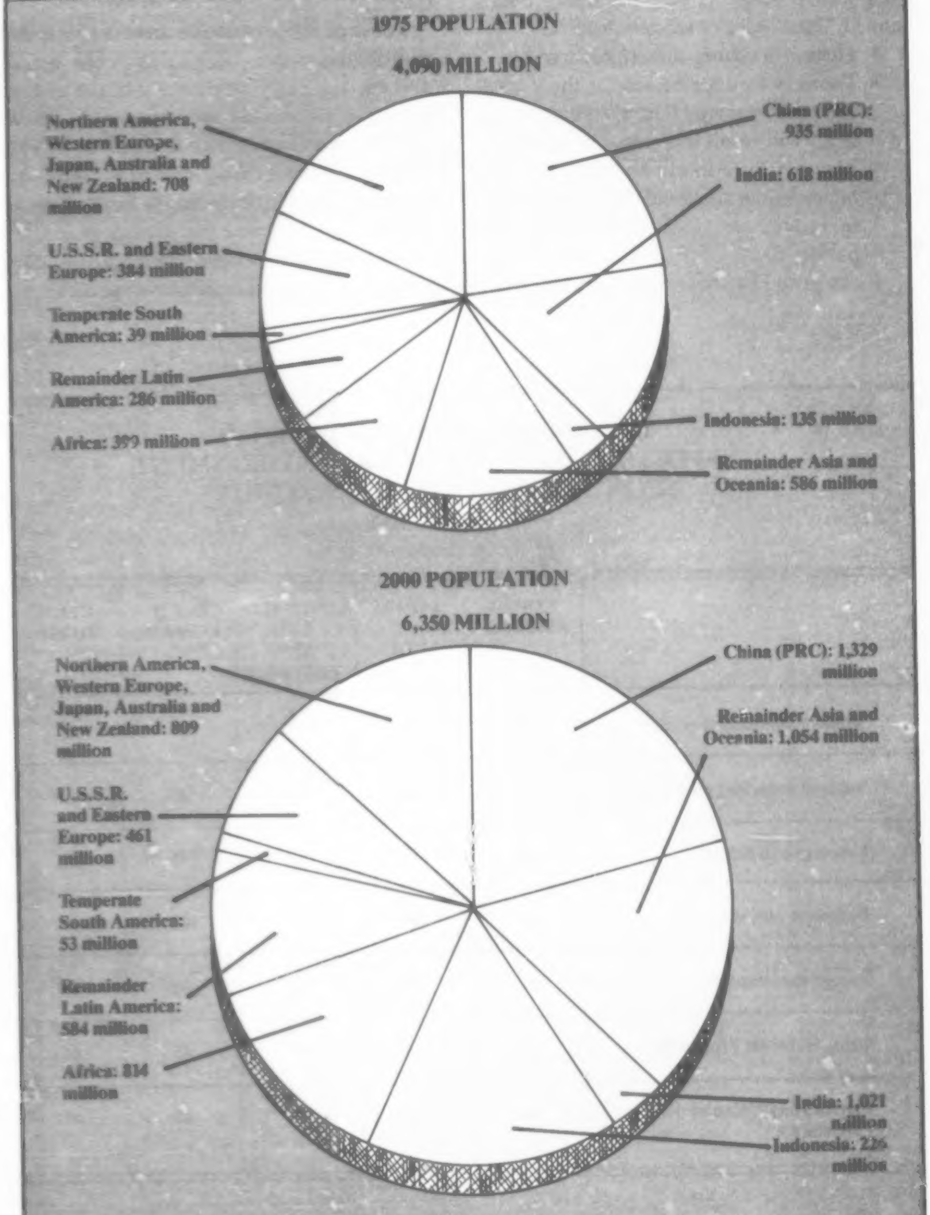
- known problems of known scope;
- known problems of unknown scope;
- potential problems contingent on technological, economic, or other discontinuities or changes in trends;
- unknown problems which are potentially discernible;
- unknown problems not likely to be discernible.

The mainstream of Agency research and regulation focuses on the environmental problems of the first class, where the effort involves precise quantification of problem and scope and appropriate regulatory response. The areas of greatest interest for the anticipatory research program, however, are the middle three classes where we can bring light to poorly understood problems, identify the lead indicators of changing trends, and uncover altogether new and pressing environmental issues.

When looking to the future to study environmental problems it is often more advantageous to look at their potential sources than at the problems themselves. To this end, we have categorized the seven most prolific sources of such problems:

- driving forces of population and economic growth;
- new technological development;
- wider scale, or more intensive, use of established technologies;
- latent or dormant problems in current technologies which may surface in the future;
- neglect in planning for the total life cycle of a technology;
- new knowledge resulting from sensitive measurement and detection capabilities;
- changes in social attitudes and values.

TWENTY-FIVE YEARS OF POPULATION GROWTH: MEDIUM SERIES



SOURCE: Department of Commerce, Bureau of the Census, "Illustrative Projections of World Populations To The 21st Century," Current Population Reports, Special Studies Series, 23, No. 79.

As a result of a thorough study of problem sources, many of tomorrow's problems have already been recognized and are receiving considerable attention in ORD's research program. In general, these problems, for which there is now a firm basis for concern, and whose scope is being actively determined, share three characteristics:

- There is a clearly discernible trend;
- There is an experiential or theoretical basis for believing that, if continued, the trend will result in a major problem;
- There is little likelihood that, without intervention, the trend will change so as to reduce or modify the impending problem.

Risks posed by these future problems are many. Two significant examples directly tied to the driving forces of population and economic growth, for example, include the greenhouse effect from carbon dioxide and the alarming increases in acid deposits resulting from the wider scale and inadequately or uncontrolled use of fossil fuels.

These problems also illustrate the profound implications that a shift in scale which exceeds the carrying capacity of the system can have. A second set of potential future problems currently under study involves new technologies and their potential for introducing materials into the biota alien to its genetic experience. Such are the stresses placed on the biota from modern chemical industry waste products and microwave radiation.

GROWTH OF HUMAN ACTIVITIES AFFECTING THE STATE OF THE ENVIRONMENT, SELECTED INDICATORS, BY REGIONS, 1965-1975

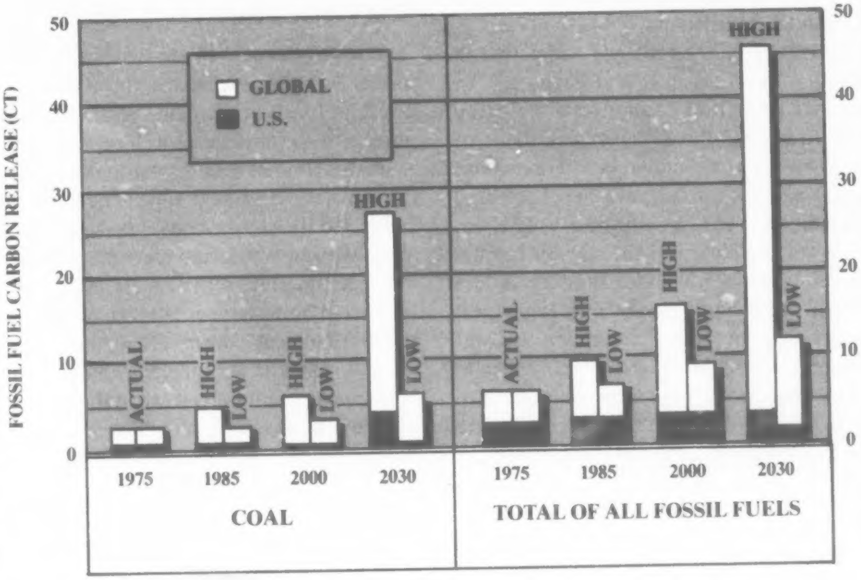
Percentage increase 1965-1975

	NORTH AMERICA	JAPAN	AUSTRALIA AND NEW ZEALAND	OECD EUROPE	OECD TOTAL
Value of agricultural production	23	25	23	24	23
Value of industrial production	30	124	39[c]	42	42
Urban population (a)	21	19	22	19	20
Passenger cars in use	45	684	71	100	75
Energy consumption	41	119	58	39	46
Gross Domestic Product (b)	33	125	54	45	44
Private Final Consumption Expenditure	42	112	57	48	49

(a) OECD estimates. (b) 1970 prices and exchange rates. (c) Australia only.

Source: OECD, The State of the Environment, Paris 1979, page 41.

U.S. AND GLOBAL CONTRIBUTIONS TO TOTAL FOSSIL FUEL-INDUCED CO_2 RELEASE



Sources: Chen, K., R. C. Winter, and M. K. Bergman, "CO_2 from Fossil Fuels: Adapting to Uncertainty," submitted for publication.
Note: These hypothetical high and low growth projections bracket any likely future growth in fossil fuel-incuded CO_2 releases.

Many future environmental problems will also arise as the result of a past neglect of the full life cyce of a technological system, or from current industrial practices that hide problems. There are today, for example, virtually thousands of industrial waste sites which may contain hazardous chemical wastes and which may present future problems. In the case of Love Canal and the Valley of the Drums, two instances where severe damage has already taken place, these problems were not identified until toxic wastes created highly undesirable consequences.

Aquifer degradation from the combination of excessive depletion of water tables and the introduction of contaminated replacement water is another example of a potential, latent, life cycle problem. This problem may become particularly severe in the West with the development of new energy souces. Large-scale exploitation of fossil fuel resources in the West may also result in latent environmental hazards posed by pollutants leaching from waste heaps. Prevention is complicated by the high cost of plant growth to restrict leaching, and the difficulty of stabilizing the heaps against landslides.

New concerns can be created or uncertainties clarified as results from new epidemiological studies or from refined physical, chemical, and biological detection techniques become known. The relationship between cigarette smoking and lung cancer is the classic example. More recently, research defining the subtle side effects of microwave radiation illustrates the potential for new knowledge to focus concern.

Changes in social attitudes and values are also coming to be recognized as a major source for potential environmental impact. The migration to the so-called sun belt, for example, coupled with the tendency of migrants to attempt to recreate their previous environment is bringing about major environmental stresses. The extreme air pollution on the front range of the Rockies around Denver is a now well-established example of how mass immigration can impact a fragile and limited environment.

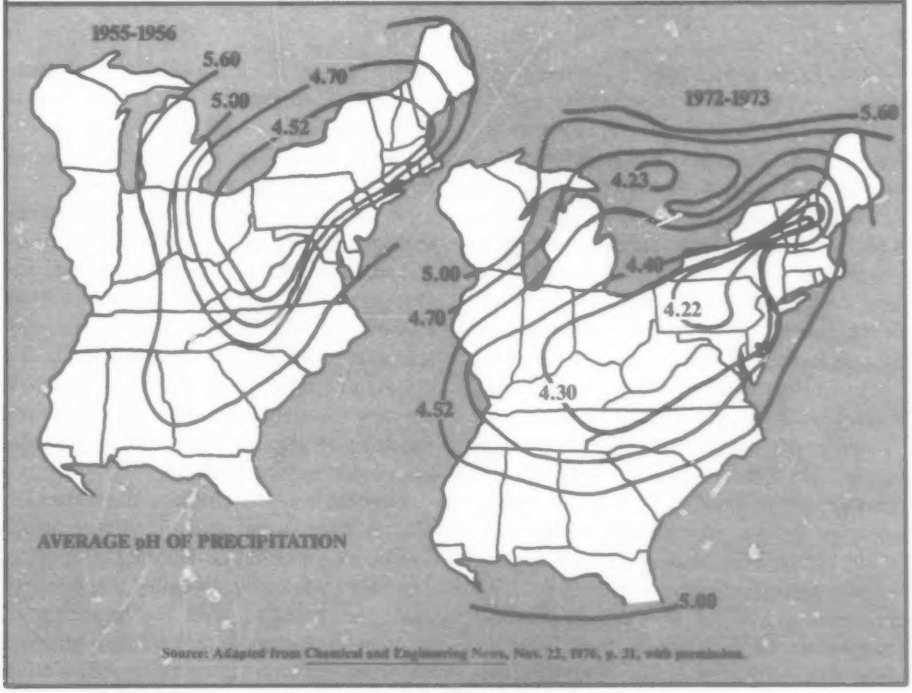
Current program research addresses all these problems, issues, and concerns. To prepare for the future, all efforts are being made to change those known problems of unknown scope to known problems whose scope is also known, but a number of potential problems are yet to be fully defined. Here, trends are less clear and the experiential and theoretical base for understanding is less certain. Still, many may deserve wider attention by the policy and research communities now, if for no other purpose than to clarify their potential significance and to define a well-ordered strategy for coming to a fuller understanding of their management.

New Chemical Industries—New Environmental Problems

The products and by-products of the nation's chemical industries pose among the most pervasive, diverse, and intractable threats to our environment.

Petroleum has been the basic feedstock of the synthetic-organic chemical industry. That basic feedstock may change, however, as coal, liquids, wood, and other plant products become more attractive, more economical, and more able to meet environmental standards. Chemical industry production processes may also change radically, as biological and biochemical know-how points to more effective methods. Finally, the end products and by-products of the chemical industry may

ACIDITY OF PRECIPITATION OVER EASTERN U.S.



Source: Adapted from Chemical and Engineering News, Nov. 22, 1976, p. 21, with permission.

CLASSES AND CAUSES OF FUTURE ENVIRONMENTAL PROBLEMS

CAUSE OF PROBLEM	POTENTIAL PROBLEM	DESCRIPTION	CLASS OF PROBLEM
Changes in social values.	Indoor pollution from domestic toxic materials, such as carbon monoxide and accumulation of offensive odors.	Energy conservation in space heating results in substantially lower rates of air turnover.	Known problem, unknown scope.
New knowledge.	Removing or adding trace materials in the human, animal, and plant environments.	Growing knowledge of the role of trace materials, and increasingly sensitive instruments for their detection and measurement may call for new measures to regulate trace materials.	Known problem, unknown scope.
Population and economic growth.	Irreversible melting of the polar ice cap.	If the greenhouse effect from carbon dioxide in the atmosphere, from expanded use of organic fuel, is a real threat the heat could melt the ice at the poles and flood most coastal areas.	Unknown problem, potentially discernable.
Neglect of life cycle.	Clean up after a nuclear event or reactor decommissioning.	We may be unprepared to clean up after a nuclear power plant accident or a limited nuclear exchange.	Known problem, unknown scope.
Neglect of life cycle.	Dam silting.	A major spate of contemporary dam building occurred during the second quarter of the 20th century. Therefore, during the first part of the next century silting may become a world-wide problem. Only two of the 25 largest dams in the world were completed before 1955 (1932 and 1940).	Known problem, unknown scope.
More intensive use.	New environmental pollution from cadmium, lead, sulfur, zinc, nickel, and other materials.	It is plausible that electric cars may develop into a substantial fraction of the auto fleet. They would have to use some kind of battery storage system based on lead, mercury, cadmium, sulfur, zinc, nickel, or other materials not now generally deployed in the environment in large quantities.	Contingent problems.
New technology.	Ocean pollution from industrial pollution.	With the large scale mining of the seabed resources possible, we find that we have relatively little understanding of the effects of the oceanic equivalent of mine tailings. Mine operations are likely to raise large quantities of trace materials, as well as vast quantities of particulates, into the life zones of the ocean.	Contingent problem.

CLASSES AND CAUSES OF FUTURE ENVIRONMENTAL PROBLEMS

CAUSE OF PROBLEM	POTENTIAL PROBLEM	DESCRIPTION	CLASS OF PROBLEM
More intensive use.	Rural land pollution.	The general lack of land use control in rural America coupled with the increasing rate of introducing new technologies into rural America will lead to greater waste disposal, land pollution and aesthetic problems.	Known problem, unknown scope.
Scale.	Destruction of ancient and modern architectural and structural artifacts.	As industrialization proceeds in the Third World, at current low standards of pollution control, structural artifacts and art work, such as the Taj Mahal, will undergo serious deterioration.	Known problem, unknown scope.
Neglect of life cycle.	Urban vermin.	Rats, roaches, and other vermin in urban areas are increasingly resistant to control agents, while the use of control agents is being more restricted. Aside from the offensive nature of vermin, they are disease vectors.	Known problem, unknown scope.
Neglect of life cycle and scale.	Sulfur wastes.	The growing use of sulfur-rich fossil fuels will, under present regulations, lead to the accumulation of large quantities of sulfur from de-sulfurization. Disposal presents problems.	Known problem, unknown scope.

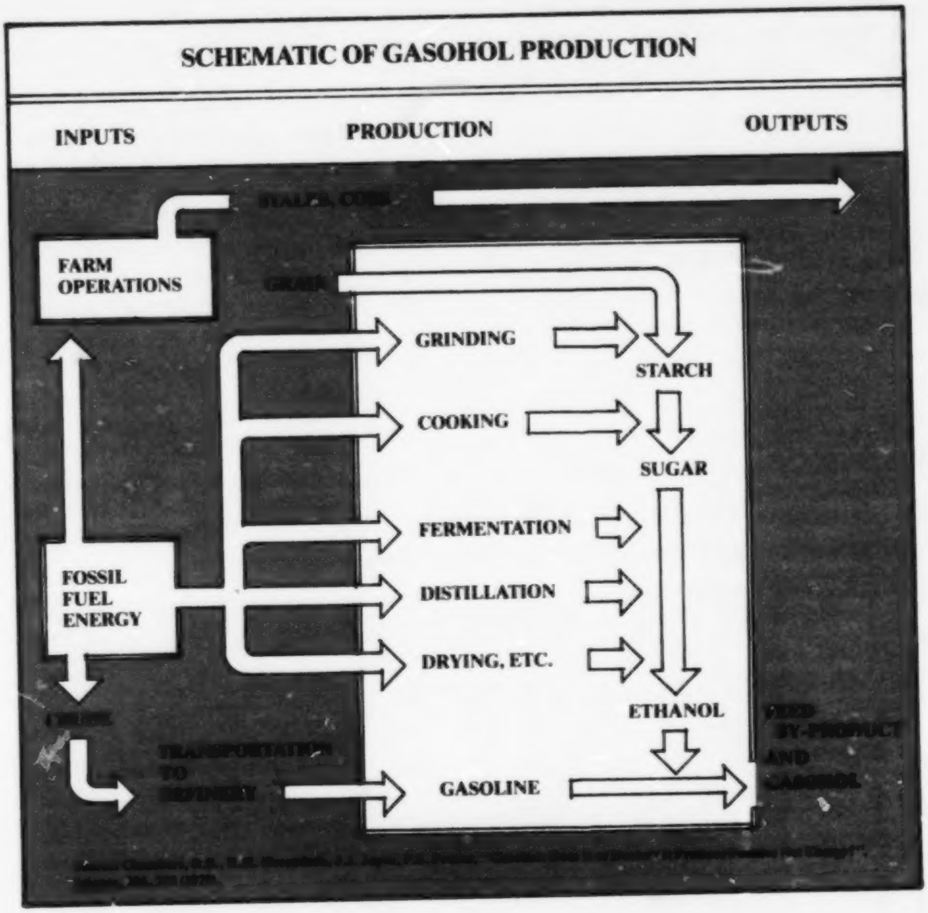
themselves be different, as in the future new chemicals based on new feedstocks and new processes are produced, and as new materials and uses are required.

Major changes in the chemical industry are not only the result of the quest for new discoveries. Many new industries or relatively unimportant industries and processes have been stimulated or changed as the chemical industry as a whole works to accommodate present energy and environmental problems. This chapter reviews some impending changes and their environmental implications. In almost every case we will be dealing with feedstocks, processes, and products that may present new or unsuspected problems of unknown scope.

Some New Chemical Feedstocks

The primary impetus behind the recent interest in wood is its potential as an energy source. Once, however, the technological capabilities are in place to continually cultivate, harvest, distribute, and process large quantities of wood as an energy source, the next obvious step will be to consider wood as a feedstock for basic industrial chemicals. At least four wood compounds are attractive in this regard: cellulose, lignin, vanillin, and terpenes (which are polymers of isoprenes and in the family of chemicals related to turpentine).

Research into the use of these raw materials



SCHEMATIC OF GASOHOL PRODUCTION

INPUTS
PRODUCTION
OUTPUTS
STALKS, COBS
FARM OPERATIONS
GRAIN
GRINDING
STARCH
COOKING
SUGAR
FERMENTATION
FOSSIL FUEL ENERGY
DISTILLATION
DRYING, ETC.
ETHANOL
CRUDE
FEED BY-PRODUCT AND GASOHOL
TRANSPORTATION TO REFINERY
GASOLINE

[illegible]

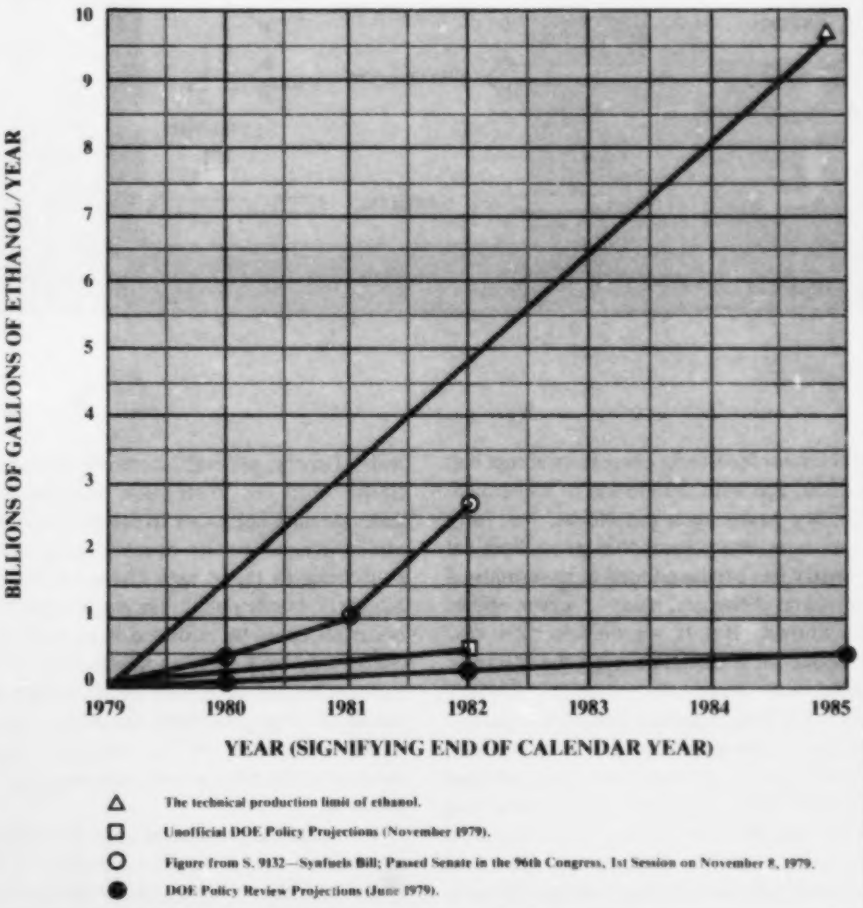
as chemical feedstocks came to an abrupt halt decades ago with the growth of a chemical industry based upon petroleum. For forty years now, the commercial petrochemical industry has produced tens of thousands of individual chemicals, many of whose effects are known. But if we turn to new raw materials, it is uncertain what the nature of these new chemicals might be. Today, relatively little is known about the nature of the tens of thousands of compounds which could be produced from a wood base and used as herbicides, pesticides, monomers, and polymers. Families of chemicals based on terpenes or vanillin may, for example, turn out to be substantially more or less threatening to people and to the biota than petrochemicals. Timely, general laboratory investigations could establish such patterns and generate data necessary to inform decisions about promoting or discouraging mass switching to these new chemical bases. Similarly, public policy concerning these raw materials could be informed in an early and useful way by a clear understanding of the total cycle involved in their use, to include the nature of wastes generated, alternative modes of waste disposal, and the impacts of these wastes on the natural and man-made environment.

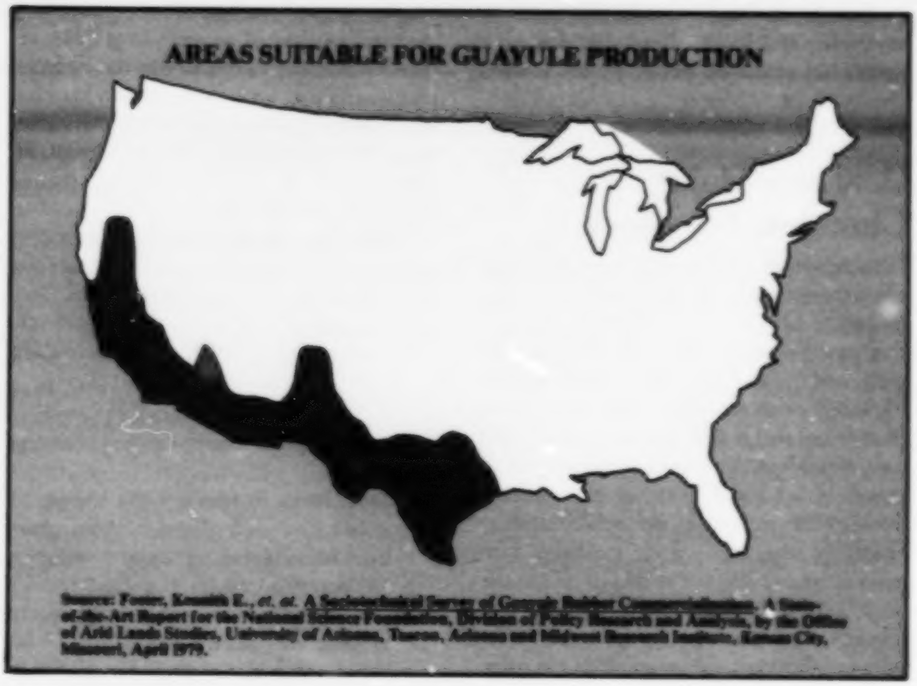
The potential production of alcohol-based automobile fuel is another example of the chemical industry's response to the growing concern over the nation's energy independence and the rising cost of petroleum.

With the widespread use of alcohol-based fuels, or gasohol, numerous problems will be presented. At the use end, it is known that a large percentage of automobiles operate at far from optimum tuning, timing, and combustion efficiency. Consequently, we may expect that the production of partial combustion products, such as acetaldehyde, resulting from use of these fuels may create new and/or severe air pollution problems, though as it stands today, our alcohol-based fuel emissions data is not adequate to tell us to what degree — a potential problem of unknown scope.

The major environmental problems from the use of gasohol, however, may not result from its combustion, but rather from gasohol production. These risks have recently been inventoried in an Office of Technology assessment memorandum. Using sugar and starch as the alcohol base, it was estimated that to have a significant effect on automotive fuel cost and availability, as many as 30-70

PROJECTIONS OF ETHANOL PRODUCTION





AREAS SUITABLE FOR GUAYULE PRODUCTION

Source: Foster, Kenneth E., et. al. A Sociotechnical Survey of Guayule Rubber Commercialization, A State-of-the-Art Report for the National Science Foundation, Division of Policy Research and Analysis, by the Office of Arid Lands Studies, University of Arizona, Tucson, Arizona and Midwest Research Institute, Kansas City, Missouri, April 1979.

million *additional* acres in intensive crop production would be required. This, in turn, implies:

- accelerated erosion (5-10 ton/acre/year);
- increased pesticide use;
- increased demand for natural gas for fertilizers;
- turning 10-30 million acres of unmanaged ecosystems (forests) into managed ones (crop lands).

Distillation of the sugar and starch to remove the alcohol implies:

- pollutants from coal or biomass combustion used to power the distillation process (50,000-70,000 BTU/gal);
- chemical and biological oxygen demand of effluents from "stillage";
- difficulty of monitoring decentralized distillation of gasohol.

Guayule, a plant indigenous to the southwest United States and Mexico and a potential source of natural rubber, is a somewhat esoteric example of a potential environmental pollutant. Guayule was evaluated on a pilot scale during World War II as a source of rubber. Those investigations demonstrated unequivocally that the latex produced by that plant is effectively the equivalent of latex from rubber trees. Latex is a polymer of isoprene, which in turn is related to the class of chemicals known as terpenes, mentioned earlier. The extensive future use of guayule, however, would also present the complex, systemic problems that would accompany the movement to a wood-based chemical industry or to gasohol production.

A specific environmental problem resulting from the large-scale cultivation of guayule could be the release of terpenes into the atmosphere in such quantities as to create a haze of oxidizable hydrocarbons. Such a terpene haze hangs over and provides a name for the Great Smokey Mountains. While a similar problem may not occur in most places, several areas well suited for growing guayule are near urban centers with already significant air quality problems.

This potential problem is notable since it is assumed that guayule will either be ignored as a source of latex rubber or become a massive new cultivated crop, effectively responding to the demands for natural latex rubber. Early experiments on plant characteristics and their environmental implications could have a significant effect on public policy toward promoting or discouraging guayule cultivation.

Coal as a Major Chemical Feedstock

There will almost certainly be an expanded use of coal as an energy source. Consequently, coal is already the subject of extensive environmental pollution research. As with wood, we may anticipate that the increased availability of liquids fuels (syncrude) from coal as energy sources will lead to consideration of these same liquified fuels as chemical feedstocks. However, solvent-refined coal yields liquified fuels containing relatively large amounts of aromatic compounds whose chemical nature raises the possibility of potential health effects. It is already well known, for example, that polynuclear aromatic compounds are often carcinogenic. Liquified fuels refined from oil shale, an alternative to coal, will also contain polynuclear compounds which carry carcinogenic and other health threats. The gasification of coal, and alternative method to produce liquid fuels (methanol), raises problems analogous to those already discussed in gasohol. Additionally, as with wood, the wide-scale adoption of methanol as a basic chemical feedstock raises the question of its potential to generate new environmental problems.

Biotechnology— A Chemical Biological Process Revolution

Our growing ability to manipulate genes in lower and higher organisms places us on the brink of many new industrial processes. This biotechnology industry is likely to begin with the manipulation of genetic material in bacteria and other single cells organisms, and then progress to higher species. Virtually nothing is known, however, about the potential environmental problems associated with such an industry. The concerns to date have largely focused on limited but significant public health threats thought to be potentially posed by genetic manipulation. Concern over the implications of recombinant DNA research was initially expressed by the scientific community and later by the general public. This concern has been manifest in 16 congressional bills, a scattering of local legislation, and volumes of congressional reports and hearings—all since 1974.

Today there are about 400 applied genetics research and development projects underway in 15 countries. The scientific base generated by these projects is likely to explode into many applications in the years ahead. Projects include:

- invstigating the use of bacilli to improve natto (fermented soybean) production in Japan;
- procedures to transfer the ability to utilize nitrogen to plants by using genes from bacteria transmitted by a virus;
- production of insulin by bacteria;
- production of viral antigen for use in vaccines by bacteria; and
- use of bacteria to produce biochemicals of industrial importance.

The potential applications of this technology are limited only by the imagination.

Although precise figures are not available, it is known that most large pharmaceutical companies are investigating biotechnology, and that four firms have been founded since 1971 primarily to explore these new genetic horizons. The market value of these firms is estimated to be $225 million dollars.

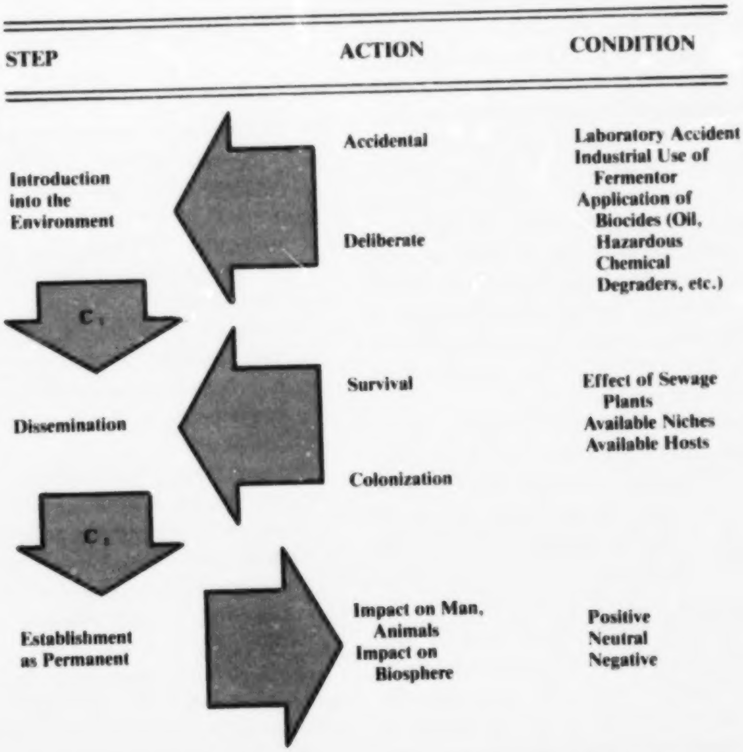
The potential for the rapid and vast growth of biotechnology points to the need for timely investigations into its possible environmental effects. For example, while the agricultural industry would benefit from crops genetically engineered to require little or no nitrogenous fertilizer, the environmental ramifications of such plants, ones which could outgrow their neighbors, should be considered. Similarly, while the benefits of producing an organism capable of rapidly converting cellulose to alcohol are obvious, its consequences on the environment are not. What is to keep this organism from multiplying beyond our need for it? What risk could it pose?

While most such research has emphasized direct containment of hazards from such organisms, manipulated organisms could still accidentally be introduced into the environment. Moreover, many of the potential future applications of this technology, particularly in agriculture, would call for the deliberate release of these organisms. Once released, their dissemination depends upon whether they survive and/or colonize. Once established in colonies, they could possibly impact severely on the environment. Thus, direct containment of the manipulated organism is only a part of the potential environmental concern.

To date, academic biotechnical research has generally been voluntarily conducted under guidelines established by the NIH (although 13 countries with ongoing RDNA research have no guidelines). Significantly, no adverse effects have been detected, and the results of a number of experiments have indicated that there may, in fact, be less danger than had been anticipated. These findings have led to the relaxation of the original academic research guidelines, which were highly restrictive.

Guidelines have not been extended to industrial laboratories, although voluntary compliance has been the rule. However, the question of ecological impact has not been investigated, a question that may be of the

UNDERSTANDING MANIPULATED ORGANISMS AS AN ENVIRONMENTAL HAZARD


STEP
ACTION
CONDITION
Introduction into the Environment
Accidental
Deliberate
Laboratory Accident
Industrial Use of Fermentor
Application of Biocides (Oil, Hazardous Chemical Degraders, etc.)
C_1
Dissemination
Survival
Colonization
Effect of Sewage Plants
Available Niches
Available Hosts
C_2
Establishment as Permanent
Impact on Man, Animals
Impact on Biosphere
Positive
Neutral
Negative

The probability for each step must be either measured or estimated. The total probability of establishment as a permanent species will be the product of the individual values. Thus, if either C_1 or C_2 were zero, no permanent impact would be expected.

greatest concern in industrial settings, owing to the potential quantities of artificially produced organisms that may eventually be involved. In any event, the profound implications of the industrialization and the widespread agricultural application of synthetic and manipulated organisms must be understood as a basis for making well-informed environmental policy. Research initiated by ORD in FY1980 marks the beginning of this wide-ranging examination.

A New Chemical Product —Composite Materials

A major future problem might potentially be posed by the increased use, recycling, and combustion of composite materials. These innovative composites, fiberglass being the most common, are usually made up of microscopic fibers of high strength materials such as carbon, beryllium, quartz embedded in a matrix. Dispersion of these fibers into the environment and subsequent uptake by humans may lead to diseases analogous to black lung, bageosis, asbestosis, and other chronic illnesses known to result from the inhalation of microscopic fibers. Such health impacts are of primary EPA concern. A second, more specific, concern involves carbon fibers and their characteristics as electrical conductors. These fibers are currently an element in composites being used in high performance aircraft. In the event of an accident, the resulting fire or explosion could release vast numbers of these carbon fibers into the atmosphere. When these particles settle, it is feared that they may have a highly disruptive effect on electric motors and other electrical equipment. A government-wide study of composite materials is now in progress under the Office of Science and Technology Policy.

What To Do

The development of alternative feedstocks and alternative fuels, the move to new resources and materials, and the search for new organisms all pose environmental problems. Several of these problems are already known, but are of unknown scope, while the existence and significance of others has yet to be discovered. Still other problems are highly conjectural, but are, nonetheless, of major potential import. In any case, however, the need for anticipating these problems and planning for their solution is clear. Such anticipatory knowledge and future-oriented strategic planning requires:

- Examining technologies in their total economic, social, and institutional context.
- Examining the total life cycle of a technology from its earliest research and development stages through demonstration, pilot testing, practical application, growth, and the ultimate disposal of waste and dismantlement of facilities.
- Recognizing that field and laboratory research are among the most effective means of enlightening decisions; while some research must be fundamental and long-term, such as effects studies involving weather, ecosystems, and epidemiological consequences, short-term laboratory and field investigations may be adequate for clarification of key uncertainties.
- Giving explicit attention when studying technologies to their potential side effects and unanticipated consequences, so frequently the origin of environmental problems.
- Monitoring the environment, technological change, lead indicators, and social values to expand the policy decision-making information base, and to gain an understanding of problems not accessible through standard field and laboratory research.

Such health impacts are of primary EPA concern.

To fulfill the anticipatory research program's objective of developing an early understanding of potential problems, and either short circuiting them or moderating their consequences, policy makers and the concerned public must be kept abreast of these problems and of their implications for policy.

Anticipating Problems and Exploratory Research

To best support EPA's basic mission, the search for and anticipation of future problems must be linked to systematic exploratory research, capable then of determining the scope and significance of these problems. Several steps are currently being taken to improve ORD's strategic, anticipatory, and exploratory research capabilities. One such significant step is the ORD Office of Exploratory Research. The overall goal of this office is to identify and forecast new problems and to build the scientific foundation for their future study within EPA's regulatory research programs. Specific objectives are to:

Several steps are currently being taken to improve ORD's strategic, anticipatory, and exploratory research capabilities.

- Establish an Agency interdisciplinary strategic analysis capability to determine future environmental trends, and to identify and evaluate potential environmental problems. The resulting forecasts will then take into account the full life cycles of new and existing technologies (including ultimate disposal), will identify their side effects, and will base quantitative growth projections on a full examination of all the driving forces behind their development. These forecasts will be incorporated into an annual *Environmental Outlook* report.

  In many cases, the forecasts will begin with an assessment that clarifies the seriousness of a problem and the extent to which it demands further consideration. These may be broad, integrated assessments, such as those found in the 1979 EPA *Energy From the West* forecast for energy development in the western United States, or they may be mini- or small-scale assessments. Results from such forecasting activities may in some cases lead to larger-scale special studies to develop more in-depth knowledge on a specific problem or category of problems. One such study now underway is EPA's acid rain research program, an outgrowth of an anticipatory research effort that is currently at the point of maturing into a full-scale ORD research activity.
- Establish a series of institutional research centers to complement EPA laboratories and foster long-term studies of the environment. Four such centers have already been established (groundwater at the University of Oklahoma, Rice University and Oklahoma State University, epidemiology at the University of Pittsburgh, basic environmental control technology at the University of Illinois, and marine sciences at the University of Rhode Island) and additional centers are in the planning stage. These centers will provide the nucleus for ORD's long-term research and will be a key component in ORD's expanding effort to explore new problems.
- Build a strong research grant program to provide support for the best scientific ideas and research scientists. As it enters the 1980's, EPA research must delve deeper and yet more imaginatively into the mysteries of the environmental sciences to reach the new plateau of scientific understanding vital for our age and future ages. EPA must now go beyond the traditional defensive research of the 1970's. To this end, ties to the university community will be strengthened, and a climate of cooperation will be fostered among government laboratories, universities, and industrial research institutions.

These initiatives provide an enlightened framework for developing new knowledge and exploring new problems. They combine to form a foundation for the 1980's and beyond; they build on the past, and point over the horizon to assure a better future.

APPENDIX A
RESEARCH OPTIONS

The plans discussed in the previous chapters of **Research Outlook 1980** reflect the priorities set and research needs defined through the new research committee system. The following outline of research options and resources is also an outgrowth of the new committee system. At present, there are two research areas for which no research committee exists—anticipatory research and noise. Anticipatory research is currently being evaluated to determine how it best can be served by the committee system; noise research is currently administered by the program office. Both are presented here in separate discussions.

For each of the following sections, three separate research scenarios are described: no budget growth, moderate budget growth (5% per year) and high budget growth (10% per year). The resource projections, in constant dollars (thousands), are based on the FY 81 President's budget submission, with FY 80 resources included for comparison. It is to be noted that the percentages being used to quantify growth are estimates, and may, in fact, be reduced in some areas as the fiscal year proceeds, or may, in certain critical areas, be exceeded. For the purposes of this document, however, they serve as overall yardsticks for comparative multi-year program projections.

Toxics

Chemical Testing and Assessment Research Committee

CHEMICAL TESTING AND ASSESSMENT RESEARCH COMMITTEE

Fiscal 1980: $27,820

GROWTH	1981	1982	1983	1984
NO	36,538	36,538	36,538	36,538
MODERATE	38,365	40,283	42,298	44,413
HIGH	40,192	44,211	48,632	53,496

All figures shown in thousands of dollars, and rounded to the nearest thousand

No Growth Scenario. Under a no growth budget, our research effort will be directed toward the continued development of health and environmental test methods and standards for characterizing toxic chemicals and their fate. Simple test procedures will be developed to determine whether a given substance requires further investigation. If such a need is indicated, more extensive, confirmatory tests will be used to better quantify the nature of the substance. This extensive testing will then be followed by hazard assessments to evaluate, through workable models, the pathways and effects of human and environmental exposure. EPA guidelines and protocols will ensure the adequacy of tests which may be used by industry laboratories to test new chemical substances.

Moderate Growth Scenario. We will continue development of the scientific data base necessary to clearly evaluate exposure levels and resulting hazard potentials to humans and the environment from a variety of pollutant concentrations and transport pathways. The parameters of environmental exposure including chemical release, fate, use, distribution and disposal and resulting ecosystem effects will be studied in detail. The parameters of human exposure, particularly molecular indicators that determine chemical presence and dose, will be studied for several classes of compounds. This dosimetric information will then be correlated with data on mutation and tumor induction developed in short term *in vitro* and *in vivo* bioassays. Metabolism and target organ toxicity studies will be accelerated and expanded to include multiple species; this so that more and better data can be generated to extrapolate to the human level. Monitoring technology will be improved especially for multi-species detection and quantification. This information will be used in concert with health and environmental effects data in recommending alternative manufacturing and/or processing options to industry.

High Growth Scenario. We will perform health and environmental effects research modeling using systems that take into account the multiple interactions of toxic chemicals occuring in the environment and in receptor organisms including man. These data are essential in any assessment of the environmenetal impact of toxic chemical release.

Air

Hazardous Air Pollutants Research Committee

HAZARDOUS AIR POLLUTANTS RESEARCH COMMITTEE

Fiscal 1980: $8,324

GROWTH	1981	1982	1983	1984
NO	9,590	9,590	9,590	9,590
MODERATE	10,069	10,573	11,101	11,656
HIGH	10,549	11,604	12,764	14,040

All figures shown in thousands of dollars, and rounded to the nearest thousand

Under Section 112 of the Clean Air Act Amendments, the term "hazardous air pollutant" is defined as "an air pollutant to which no ambient air quality standard is applicable and which in the judgment of the Administrator causes, or contributes to, an increase in serious, irreversible, or incapacitating reversible illness." The Office of Research and Development's research on hazardous air pollutants has focused on vinyl chloride, benzene, mercury, cadmium, asbestos, beryllium, etc. Over the next several years, ORD's emphasis will be shifting from research on the heavy metals to more research on organic chemicals that have a high potential for being human carcinogens. ORD's basic support activities for this program include: *in vitro* animal toxicology and epidemiological studies, identification and characterization of hazardous air pollutants, determination and verification of emission factors including the transport and fate of pollutants, and their transformation rates in the atmosphere, and development and verification of monitoring and control devices.

No Growth Scenario. In response to the growing need to identify and understand the hazardous air pollutants present in ambient air, increased program emphasis will be placed on pollutant characterization. With a constant total budget, increases in this area will be offset by decreases in research examining the noncarcinogenic health effects of hazardous pollutants.

Moderate Growth Scenario. With a five percent budget growth, the non-carcinogenic health effects work could be retained. Efforts in ambient air characterization could also increase.

High Growth Scenario. Ten percent growth would enable ORD to develop validation monitoring methods. These methods would be used to verify the effectiveness of hazardous air pollution controls.

Oxidants Research Committee

OXIDANTS RESEARCH COMMITTEE

Fiscal 1980: $16,117

GROWTH	1981	1982	1983	1984
NO	17,189	17,189	17,189	17,189
MODERATE	18,048	18,951	19,898	20,893
HIGH	18,908	20,798	22,878	25,166

All figures shown in thousands of dollars, and rounded to the nearest thousand

Carbon monoxide, ozone, photochemical oxidants and nitrogen oxides are the air pollutants that fall within the purview of the Oxidants Research Committee. By 1983, ORD must present an updated data base to support maintenance or revision of the Ambient Air Quality Standards for ozone, photochemical oxidants and nitrogen oxides. ORD's major research activities to improve the data base for these pollutants are : acute and chronic animal toxicological studies, controlled human exposure (clinical) studies, epidemiological studies, studies to detect, understand and predict the impact of these pollutants on terrestrial ecosystems, studies on the transport and fate of these pollutants in the atmosphere, and research on the development of new and/or improved methodologies and instruments.

No Growth Scenario. In accordance with criteria document revision schedules, ozone health effects research will diminish following publication of test results. Subsequently, carbon monoxide health effects work will increase. Oxidant characterization, transport and fate, and control technology research levels should remain relatively constant.

Moderate Growth Scenario. With growth in the budget, we will study the health effects of additional photochemical oxidants such as nitric acid, PAN and formaldehyde. We will also undertake more studies of the health effects of chronic exposure to ozone, nitrogen dioxide and carbon monoxide.

High Growth Scenario. This scenario will enable us to develop and validate ozone and NO_x models that can predict the impact of powerplants on distant areas. This information will help EPA in determining the allowable increments of these pollutants for those areas protected by the Prevention of Significant Deterioration provisions of the Clean Air Act.

Gaseous and Inhalable Particles Research Committee

GASEOUS AND INHALABLE PARTICLES RESEARCH COMMITTEE

Fiscal 1980: $32,993

GROWTH	1981	1982	1983	1984
NO	43,418	43,418	34,418	34,418
MODERATE	36,139	37,946	39,843	41,836
HIGH	37,860	41,646	45,811	50,392

All figures shown in thousands of dollars, and rounded to the nearest thousand

Over the next few years, major emphasis will be placed on developing short-term tests which can help us assess the chronic health effects of exposure to gaseous and particulate pollutants.

No Growth Scenario. If the gases and particles budget were to remain constant, work on acute health effects would have to be reduced.

Moderate Growth Scenario. With five percent growth, we will undertake additional work to further our understanding of interregional air pollutant transport. We will also develop improved measuring techniques for use especially in conjunction with epidemiological studies.

High Growth Scenario. With ten percent growth, our program will be augmented by the development of additional source and ambient air characterization methods to assist in tracing ambient pollutants back to their point of origin.

Mobile Source Research Committee

MOBILE SOURCE RESEARCH COMMITTEE

Fiscal 1980: $8,760

GROWTH	1981	1982	1983	1984
NO	8,971	8,971	8,971	8,971
MODERATE	9,419	9,890	10,385	10,904
HIGH	9,868	10,855	11,940	13,134

All figures shown in thousands of dollars, and rounded to the nearest thousand

Diesel emissions are currently a major focus of the mobile source research program. We expect that this emphasis will diminish following pertinent regulatory actions. Development of short-term tests which can help assess health effects of chronic exposure to mobile source pollutants will, however, continue. Potential future program growth may come from the need to assess the impacts of the use of synthetic fuels in motor vehicles.

Water Quality

Water Quality Research Committee

WATER QUALITY RESEARCH COMMITTEE

Fiscal 1980: $24,379

GROWTH	1981	1982	1983	1984
NO	21,457	21,457	21,457	21,457
MODERATE	22,530	23,657	24,840	26,082
HIGH	23,603	25,963	28,560	31,416

All figures shown in thousands of dollars, and rounded to the nearest thousand

The Water Quality Research Committee is concerned with research pertaining to criteria development, non-point source assessments, dredge and fill disposal, lake protection, loading assessment, wetlands, ocean disposal, ambient toxics monitoring, socioeconomic evaluations, and the Great Lakes and Chesapeake Bay programs.

Over the next several years we expect a continued or increased demand for water quality research. During this period, EPA is likely to consolidate its programs and:

- Expand enforcement efforts for technology-based effluent limitations;
- Expand controls for toxic substances;
- Evaluate those situations where technology-based effluent limitations may not alone be appropriate, either because water quality goals cannot be achieved or because they can be achieved with lower cost alternatives (e.g., Section 301 (h) of the Clean Water Act);
- Continue evaluation of alternatives for waste disposal, such as ocean dumping or placement of dredge spoil;
- Integrate further water quality planning with water resource management efforts; and
- Continue its actions to protect sensitive systems such as wetlands.

These activities will require:

- Expanded and more efficient pollutant measurement methods accompanied by rigorous quality assurance guidelines;
- Data to support balanced health and environmental criteria for additional numbers of toxic pollutants;
- More sophisiticated and definitive methods for measuring and assessing the effects of stress on water ecosystems, including wetlands; and
- More discriminating methods for assessing the impacts on water quality of alternative pollution management strategies.

No Growth Scenario. Most research efforts are likely to remain at their current level or increase. One area that may see a decrease is research on management of nonpoint source discharges, where, over the past decade, we have developed a number of management and assessment methods currently coming into use.

Moderate Growth Scenario. With an increase of five percent we will expand our efforts in developing criteria and methods 1) for deciding which water quality situations would justify deviations from technology-based effluent standards, primarily in marine waters; and 2) for selecting and evaluating projects in which defined water quality goals for entire watersheds are to be achieved, such as those projects funded under the Clean Lakes Program.

High Growth Scenario. Under a high growth budget we will undertake a major effort to evaluate the risks to human health from polluted surface waters. In addition, we will significantly expand our development and standardization of measurement methods, primarily for toxics, as well as further increase our development and testing of criteria for achieving water quality goals through integrated watershed management.

Wastewaters and Spills

Industrial Wastewater Research Committee

INDUSTRIAL WASTEWATER RESEARCH COMMITTEE

Fiscal 1980: $18,443

GROWTH	1981	1982	1983	1984
NO	17,634	17,634	17,634	17,634
MODERATE	18,515	19,441	20,413	21,434
HIGH	19,397	21,337	23,471	25,818

All figures shown in thousands of dollars, and rounded to the nearest thousand

The Industrial Wastewater Research Committee oversees research and development on industrial effluents, recycle/reuse options and treatability.

No Growth Scenario. Under this scenario, research on health effects and marine ecology will be supported at a very low level. The industrial program will continue to rely on the health and marine ecology data being obtained as part of other non-industrial efforts in the water quality medium. In the short term, this will also be the case for freshwater ecology, although in FY82, according to current projections, freshwater research specifically tailored to industrial wastewater will be instituted. Ambient freshwater quality has become increasingly important in determining the directions taken in industrial wastewater high control technology.

Other activities, such as technical support and quality assurance, are projected at essentially constant levels. It is anticipated that moderate resources would be shifted into the control technology area.

Moderate Growth Scenario. Research aimed at developing or applying analytical methods for pollutant characterization will continue to be important under all scenarios. To optimize overall use of ORD resources, the industrial program will, where possible, obtain such data from other related ORD water quality programs. Within the industrial program itself, however, levels of support for analytical methods and pollutant characterization are estimated to remain at a constant level as need for such information will continue as new pollutants are introduced into wastewater streams.

Moderate growth scenario expansion emphasis is characterized by the increased support of freshwater ecology and control technology. Resource support for control technology will be applied principally to recycle/reuse solutions to toxic pollutant problems. The remaining areas of the industrial program would remain comparatively constant .

High Growth Scenario. In a high growth situation, the industrial program will expand on research undertaken in the preceding two scenarios. Freshwater ecology research will, for example, receive yet more support. Primary expansion will, however, be manifest in the control technology area, where again the focus would be on recycle/reuse projects. In addition, the level of support for health effects and marine ecological research will be increased for those projects targeted at industrial problems not supported through other programs.

Municipal Wastewater Research Committee

MUNICIPAL WASTEWATER RESEARCH COMMITTEE

Fiscal 1980: $21,551

GROWTH	1981	1982	1983	1984
NO	20,931	20,931	20,931	20,931
MODERATE	21,977	23,076	24,230	25,441
HIGH	23,024	25,326	27,859	30,645

All figures shown in thousands of dollars, and rounded to the nearest thousand

The research covered under this committee supports EPA activities in the areas of municipal wastewater and sludges, oil and hazardous spills, and response to controlled hazardous waste disposal sites. This latter area is currently listed as EPA's top priority and as such will require a constant level of research support for all budget options.

No Growth Scenario. Under a no growth budget, research emphasis will be placed first on uncontrolled hazardous waste disposal sites: new or improved sampling and analytical protocols and methodologies will be developed; a quality assurance program for all data developed (in support of enforcement action against the owners of these sites) will be established; and existing and proven spills technologies for remedial action will be adapted. While effort in the quality assurance area may not be as intense once the program is well in place, it is anticipated that work in the other areas will continue at least at their current levels throughout the entire five year period.

In the spills area, efforts will be placed on hazardous spill prevention, and will focus only on those prevention techniques shown by historical data to have the greatest potential for use. In the municipal wastewater area, research will deal primarily with the development and evaluation of innovative and alternative technologies with particular emphasis on energy efficiency and the use of water treatment systems for pollutant removal.

Moderate Growth Scenario. In addition to the research activities identified under the no growth option, a moderate growth budget will allow EPA to focus greater attention on hazardous spill prevention and to develop technologies for the ultimate disposal of hazardous material residues recovered during spill cleanup. For municipal wastwater and sludges, a moderate growth in the budget will enable the further development and demonstration of overland flow wastewater treatment technology. It will also enable resolution of the health issues associated with the land application of sludge and will allow for the development of the data necessary to recommend environmentally acceptable management methods for municipal wastewater sludges.

High Growth Scenario. The research activities associated with the no and moderate growth budget options will be greatly extended under the high growth option. In the spills area, it will be possible to mount a progressive program to statistically analyze historical spill data, then, based on these results, develop and demonstrate fail-safe devices for the prevention of spills in those areas of greatest potential benefit. High budget growth will also enable an analysis of the chemical manufacturing, transportation, and waste disposal industries to determine the most cost-effective technologies for handling chemicals and chemical wastes. Results of this analysis would be used to establish priorities for the development of prototype spill prevention techniques and equipment for these industries.

In the municipal wastewater and sludge area, high growth in the budget will allow EPA to address two additional areas identified as high priority by regulatory programs. Specifically, EPA would provide expert technical support and continue development of new or improved on-site wastewater management systems. EPA would also develop improved analytical protocols for toxic materials in municipal wastewater, determine the fate of toxicants in publicly owned treatment works, and develop control options and technologies to limit the discharge of toxic pollutants to the environment.

Drinking Water

Drinking Water Research Committee

DRINKING WATER RESEARCH COMMITTEE

Fiscal 1980: $22,546

GROWTH	1981	1982	1983	1984
NO	27,446	27,446	27,446	27,446
MODERATE	28,818	30,259	31,772	33,361
HIGH	30,191	33,210	36,531	40,184

All figures shown in thousands of dollars, and rounded to the nearest thousand

The Drinking Water Research Committee addresses organic, inorganic, and microbiological contaminants in water supplies. The Committee also addresses ORD's groundwater research program.

No Growth Scenario. Plans for FY81 call for an increase in the dedication of resources to water supplies serving small populations. The ultimate goal of this effort is to provide these small systems with information to evaluate an economical pollution control capability. To this end, the program will support the development of cost effective technology for small systems. The program, to be conducted at federal facilities, will also support:

(1) Provision of cost data and information on treatment methods usable by small towns;
(2) Development of a program which calls for multi-community cooperative arrangements;
(3) Evaluation of generic drinking water treatment systems to allow certification of such systems.

Since little is known about groundwater contamination, the major research effort in this area will initially involve the gathering and analysis of information. Emphasis will then be shifted toward establishing a scientific basis for developing methods to prevent or ameliorate groundwater contamination. Over the FY82-84 period, the groundwater research program will focus on four areas: (1) development of problem assessment methods; (2) characterization of the behavior of selected pollutants in the subsurface environment; (3) development of waste source control criteria; and (4) transfer of information to the user community. Under a no growth budget, the current emphasis on the health effects of organic contaminants in drinking water and the methods for their control will continue.

Moderate Growth Scenario. Under a moderate growth option, analytical methods to identify contaminants in drinking water will be developed or improved as appropriate. Groundwater research will be used to develop methods for reclaiming aquifers contaminated by toxic chemicals. Greater emphasis would also be given research into the health effects of synthetic organics and methods for their control.

High Growth Scenario. With a high growth option, the drinking water program will build on those efforts outlined in the no and moderate growth scenarios. Additionally, groundwater research will be accelerated and efforts aimed at developing more effective means for identifying abandoned toxic chemical dump sites posing a threat to groundwaters would be supported.

Owing to the magnitude and complexity of the problem, health and control technology efforts will continue to focus on the chemical contamination of water supplies. Health effects activities will center on identifying those compounds and classes of compounds posing the greatest health risks and on assessing the potential extent of those risks. Control technology activity will focus on the field evaluation of chemical contamination control systems to establish reliable cost and operating information.

Solid and Hazardous Wastes

Solid Waste Research Committee

SOLID WASTE RESEARCH COMMITTEE

Fiscal 1980: $8,596

GROWTH	1981	1982	1983	1984
NO	26,446	26,446	26,446	26,446
MODERATE	27,768	29,156	30,614	32,145
HIGH	29,090	31,999	35,199	38,719

All figures shown in thousands of dollars, and rounded to the nearest thousand

The Solid Waste Research Committee plans research for:

- Control technology for solid waste, hazardous waste and resource recovery;
- Sampling and analytical methods and protocols for hazardous waste;
- Hazardous waste risk assessment.

With the possible exception of toxics research, solid waste research, emphasizing hazardous waste, should be the major growth area for EPA over the next five years. The need for emphasis on hazardous waste research is underlined by such incidents as those at Love Canal, New York; Kin-Buc, New Jersey; Toone, Tennessee and LaBounty, Iowa, which have demonstrated the dramatic effects that past mismanagement of hazardous wastes can have. To assure that today's regulations for hazardous waste management will avert such problems in the future, it is essential that the regulations be supported by an active research program.

For FY81, EPA has developed a budget initiative for hazardous waste which would almost double the current level of solid waste research spending. A key component of this initiative is the establishment of a program to develop new or improved sampling and analytical methodologies and validation procedures for hazardous waste identification. The initiative also calls for the creation of a quality assurance program to assure the validity of all data generated. Additionally, EPA will accelerate its efforts in incinerator and land disposal research for hazardous wastes as a result of an amendment to the FY80 budget and a supplement to the FY81 budget request. Taken together, these activities represent the Office of Solid Waste's highest research priorities.

To compensate for the lack of emphasis previously given hazardous wastes under EPA's research program, all funds available under the three budget growth options for the next five years will be spent on some aspect of hazardous waste research (i.e., identification, disposal and treatment technology, and effects). Work in the area of nonhazardous waste, including resource recovery, will, for the most part, be phased out by FY81 and would only be resumed if there were a major increase in solid waste research resources.

No Growth Scenario. Under a no growth option, hazardous waste identification research during the first two to three years will emphasize the development of sampling and analytical protocols, quality assurance and the evaluation of existing procedures. During the remaining years of the plan, emphasis will shift more toward waste characterization, exposure assessment, and the development of new sampling and analytical methods. In the technology area, throughout the five-year plan, effort will be directed toward developing a technical information base which can be used by individuals writing permits for hazardous waste treatment, storage, and disposal. Research emphasis here would be placed primarily on the thermal decomposition and containment of hazardous waste. Under the no growth option little or no attention will be paid to research in hazardous waste risk assessment.

Moderate and High Growth Scenarios. To build a broad information base as rapidly as possible hazardous waste research under either moderate or high budget growth will emphasize the same key areas identified for the no growth option. It may, however, be possible to focus on waste characterization, exposure assessment, and the development of new sampling and analytical methods earlier in the planning period. In the technology area, more attention will be paid to hazardous waste treatment while efforts in the thermal decomposition and containment areas will be intensified.

The main beneficiary of increases under either the moderate or high growth options would, however, be hazardous waste risk assessment. Although the level of resources for this area will be nowhere near those for the other areas, either option would make it possible to establish a credible program dealing with the risks associated with hazardous waste exposures.

Pesticides

Pesticides Research Committee

PESTICIDES RESEARCH COMMITTEE

Fiscal 1980: $12,744

GROWTH	1981	1982	1983	1984
NO	9,436	9,436	9,436	9,436
MODERATE	9,908	10,403	11,443	12,015
HIGH	10,379	11,417	12,559	13,815

All figures shown in thousands of dollars, and rounded to the nearest thousand

No Growth Scenario. Under a no growth budget, human exposure efforts will be decreased. A small effort will be started to supplement environmental exposure studies. More resources will be applied to research on biological control methods and teratology and to the mandatory EPA Quality Assurance program.

Moderate Growth Scenario. With a moderate growth in resources greater emphasis could be placed upon: quality assurance for measurement of pesticides in agricultural soils, environmental exposure assessments, and health effects studies.

Development of test procedures for biological pesticides will also be emphasized.

High Growth Scenario. Under a high growth budget, efforts in providing quality assurance to measurement of pesticides in urban soils would be added to the program. Procedures for carrying out exposure studies will also be developed and validated for use by industry as part of its required pesticide registration procedures. Also to be developed would be short term screening procedures to reduce the time required for reproductive and teratology studies.

Non-Ionizing Radiation

Radiation Research Committee

RADIATION RESEARCH COMMITTEE

Fiscal 1980: $3,085

GROWTH	1981	1982	1983	1984
NO	3,181	3,181	3,181	3,181
MODERATE	3,340	3,507	3,683	3,867
HIGH	3,499	3,849	4,234	4,658

All figures shown in thousands of dollars, and rounded to the nearest thousand

Program emphasis in the Radiation Research Committee is on the health effects on non-ionizing radiation.

No Growth Scenario. Over the period FY82-84, a major shift in this program is expected because reaching completion will be a series of projects to determine basic health effects of environmentally significant frequencies of non-ionizing radiation. Attention will then logically shift toward research on the dose-response relationships of such effects and the effects of lifetime exposure to resonant frequencies. It is expected that this shift will be in the animal model portion of the program.

Moderate Growth Scenario. Increased levels of support realized in this program will be directed toward increasing our understanding of the interaction mechanisms that exist between electromagnetic radiation and biological systems. Theoretical studies of mechanisms will be supported and experimental studies of membrane/biopolymer responses will be accelerated.

High Growth Scenario. Under a high growth budget, the program efforts outlined in the first two scenarios will be sustained, with increased resources applied primarily in the area of human studies. For example, it will be determined whether it is necessary to replicate a current study of metropolitan area radio frequency density and cancer incidence; if replication is needed, the high growth scenario will permit its support. In addition, this scenario will permit an expansion of projected clinical investigations of populations exposed to relatively high NIR levels.

Noise

(No Research Committee)

NOISE
HEALTH EFFECTS AND CONTROL TECHNOLOGY

Fiscal 1980: $1,160

GROWTH	1981	1982	1983	1984
NO	2,227	2,227	2,227	2,227
MODERATE	2,338	2,455	2,578	2,707
HIGH	2,450	2,695	2,964	3,261

All figures shown in thousands of dollars, and rounded to the nearest thousand

The noise research effort is currently devoted to health effects studies and technology development programs which directly apply to regulatory program needs. It is administered by EPA's Office of Noise Abatement and Control.

No Growth Scenario. Under a no growth option, most funds will be applied to research on non-auditory physiological health effects for ultimate use in criteria development. Some small studies will be undertaken in sleep disturbance, community response and noise induced hearing loss. In technology development programs, primary emphasis will be placed on surface transportation noise control.

Moderate Growth Scenario. An increase in resources for noise research would be applied to initiatives in non-auditory effects, community response studies, sleep disturbance studies and initial technology related to industrial machinery noise control.

High Growth Scenario. A high growth budget would be used to expand the three priority areas of research: non-auditory physiological effects, community responses studies and sleep disturbance studies. In addition, an effort would be made to conduct special studies in the area of noise induced hearing loss. Tests and facilities would be expanded to maintain a continuing evaluation and technology validation program covering emerging technological developments.

Energy

Energy Research Committee

ENERGY RESEARCH COMMITTEE

Fiscal 1980: $101,000

GROWTH	1981	1982	1983	1984
NO	107,599	107,599	107,599	107,599
MODERATE	112,979	118,627	124,559	130,787
HIGH	118,358	130,194	143,214	157,535

All figures shown in thousands of dollars, and rounded to the nearest thousand

The Energy Research Committee addresses the environmental implications and health effects from a broad spectrum of means of producing energy. The energy production areas of concern include conventional combustion, advanced technologies for using fossil fuels, and sophisticated technologies for producing new energy supplies such as synthetic fuels.

No Growth Scenario. In the near term the role to be played by synthetic fuels in this nation will be a significant one. Accordingly, even with level funding, attention in the several disciplinary areas which constitute the energy program will be shifted toward synthetic fuel study.

In the atmospheric transport and effects area, for example, the chemical behavior and physical dispersion characteristics of synfuel plant plumes will be studied.

In the health effects area, preliminary knowledge of the hazardous pollutants that may be generated by synfuels dictates that epidemiological studies be initiated for synfuel industry workers. Initial efforts will key on industrial hygiene and close medical surveillance of the synfuel workers.

FY 80 sees the initiation of an integrated program of epidemiological, clinical and animal inhalation toxicology studies. This effort will be fine-tuned and will contribute to the review of ambient air quality standards for criteria pollutants as required by the 1977 Amendments to the Clean Air Act.

In addition to the health effects of air pollutants, the health program will also be concerned with pollutants in the form of leachates that may contaminate drinking water supplies. Epidemiological studies examining the impact of waterborne energy-related pollutants on human health are already underway. Under a no growth scenario such studies will continue. Additional research has recently been initiated on the environmental impacts of the use of synthetic fuels and other new energy technologies. It is expected that research into the impacts of pollutants from these synthetic fuel and other energy technologies will be increased in FY 83/84, as development of test methodologies and mitigation procedures for conventional energy technologies is completed. At this time, water use and impact sutdies will be expanded, and the bio-impacts of enhanced oil and gas recovery and the disposal of synfuel wastes will be evaluated. Research will also begin into the reclamation of oil shale extraction sites.

In the control technology area, the fuel extraction program will define the environmental problems associated with extraction of energy resources, including coal, oil shale, oil and gas for both traditional and advanced recovery methods. Emphasis will be placed on western coal development and its impact on surface and groundwater contamination and on those technologies close to commercialization which offer near-term, low-risk opportunities for performance enhancement and cost reductions.

Current funding levels in the control technology area will allow for preparation of synthetic fuels pollution control guidance documents and the support of control technology based standards for a few selected oil shale and coal liquefaction synfuel technologies.

Moderate Growth Scenario. In this scenario, emphasis in the health effects area will be on synfuels, and will include surveillance of synfuel industry workers and an increase in the effort to develop bioassays for detection of hazardous synfuel products and residuals. In addition, human health studies into the effects of air pollution from fossil fuel combustion will be expanded.

In the atmospheric transport and effects area, a moderate growth scenario allows for the acceleration of two efforts: synfuels and acid deposition. The nature of the synfuels effort was discussed in the no growth scenario. In light of projections that nitric acid will account for an increasing proportion of the acids in acid deposition, research efforts would concentrate on the elucidation of NO_x atmospheric transformation processes.

The environmental effects area would support studies on the biological impacts associated with the increased use of water for energy technologies. The work will be performed for basin-wide regions. Added resources would also allow for the development of water use optimization schemes for conventional and new energy technologies. In addition, field studies involving the environmental effects of acid precipitation will be expanded to provide a more complete understanding of the impact of this phenomenon on terrestrial ecosystems.

In the control technology area, beyond those efforts highlighted in the no growth option, fuel extraction studies would be performed to assess the impact of solution mining techniques for uranium extraction. Studies will also evaluate control technology for secondary and tertiary on-shore oil and gas production facilities.

The expansion of the conventional combustion program will allow for the development and evaluation of nitrogen oxide control technologies for sources other than utility and industrial boilers. Also, enhanced funding will permit development of technologies which could help abate the urban particulate problem by controlling emissions from paved and unpaved roads and other non-stack sources.

Additionally, expansion of the synfuels control technology program will allow for the publication of pollution control guidance documents and will permit development of the data base for technology-based standards for all major synthetic fuel processes in the areas of oil shale, coal liquefaction and coal gasification.

High Growth Scenario. In the health effects area, a high growth option will most significantly accelerate EPA's effort to determine the hazards associated with the synthetic fuels industry. Included in this research would be the detailed and long-term epidemiological study of workers in those countries where various emerging synfuel technologies are already in use. A high growth budget will also permit expansion of animal toxicology studies with synfuel products, by-products and residuals. Such studies could be carried out both in the worker population and for the population at large.

In the atmospheric transport and effects area, the research effort to determine rates of dry deposition of atmospheric pollution will be accelerated. Such information is needed for the development of valid air pollutant dispersion models.

In the environmental effects area, a high growth option will allow building on those research activities described in the moderate growth scenario. Specific activities will involve an accelerated synthetic fuels program to include an FY81/83 evaluation of the environmental impacts associated with development of enhanced oil and gas recovery technologies and those impacts surrounding disposal of synfuel wastes. Through this accelerated effort, the program should, by FY83, be able to provide assessment procedures and protocols for evaluating the impacts of synfuel technologies. The early reprogramming of resources in FY83 will provide additional funds for research into the terrestrial and aquatic effects of acid precipitation and will also allow for the expansion of heavy metals research into the ecological effects of wastes from surface mining activities.

The control technology area will build on those efforts described in the moderate growth scenario. Studies on fuel extraction will also be performed to determine both the adequacy of control methods and the environmental problems posed by the extraction of natural gas from unconventional sources, including tight sands, Devonian shales and geopressurized reservoirs.

Efforts in the conventional combustion program will include evaluation and development of far-term technologies still at the bench or small-pilot scale level but that offer major performance improvement potential within the next 5 to 10 years. Two current techonologies with such potential are catalytic combustion and pulverized coal NO_x/SO_x control through burner modification and alkali addition.

An increased level of resources for synfuels control technology would allow for the development of a more comprehensive and reliable data base for the preparation of guidance documents and standards. Additional synfuel facilities could be tested and assessed and the control technology test program expanded.

Anticipating Environmental Problems

Anticipatory Research

ANTICIPATING ENVIRONMENTAL PROBLEMS

Fiscal 1980: $14,600

GROWTH	1981	1982	1983	1984
NO	14,745	14,745	14,745	14,745
MODERATE	15,482	16,257	17,069	17,923
HIGH	16,220	17,842	19,626	21,588

All figures shown in thousands of dollars, and rounded to the nearest thousand

The Anticipatory Research Program was instructed in 1978 to : (1) identify and characterize emerging problems before serious environmental crises occur; (2) develop approaches for investigating long-term problems; and (3) conduct basic studies needed to support applied research activities. Given the anticipatory and exploratory character of this research, the pattern of the program's budget is one of transition as the anticipatory and exploratory mix changes and as the identification and characterization of emerging problems lead to new priorities being identified.

No Growth Scenario. Under a no growth budget, this pattern would continue, with the introduction of newly identified emerging problems limited by the resources made available when projects are completed and/or a research effort is transferred to another research program. For example, in the FY81 budget, some activities within the areas of freshwater fate studies, marine science and cancer research were considered to be sufficiently well developed to be transferred to the toxics media! budget. Special studies dealing with acid rain, biological monitoring and economic benefits research will remain at current levels.

The program would emphasize further problem identification and assessment. Based on current knowledge, high priority topics include recombinant DNA and biotechnologies, the effects of environmental pollution on the aging process and tracing the lifecycle of dangerous substances.

Moderate Growth Scenario. Under this scenario, research dealing with the deposition of dry acidic materials would be accelerated and an expanded assessment of acid rain problems beyond the Northeast could be developed. The economic benefits program would be expanded to include studies of "incidents" such as Love Canal and the aesthetic/ recreational benefits of water pollution control activities.

High Growth Scenario. Under a high growth budget, research on topics requiring long-term studies would be initiated; emphasis would be on expanded studies of basic phenomenon of interest to the mission of the EPA. Expanded studies of the long-term impact of chemical poisons on soils, of neurotoxicological and behavioral effects on humans, and of pollutant effects on terrestrial wildlife could be initiated. The scope of projects undertaken in FY79/80 at the university research centers could be expanded as the results of earlier studies identify new avenues of research.

APPENDIX B
INTERAGENCY COORDINATION

Research Outlook 1980 outlines EPA's five year environmental research and development plan. However, these planned efforts, directed to satisfy the research needs of EPA's mission, account only for approximately one-quarter of all federally funded environmental research; the remaining three-quarters is being performed by agencies other than EPA.

ORD recognizes the need to coordinate its research activities with those carried out by other federal agencies. Duplication of work must be avoided, research products must be mutually utilized, and expertise must be shared. Simply stated, all federally sponsored environmental research efforts should supplement and complement one another. To this end, ORD coordinates its efforts with over 40 federal agencies through either committee activities or joint research. We consider this coordination to be extremely valuable and plan to continue, and in some cases strengthen, these bonds in the future.

While space does not permit discussion of each interagency project, the following activities are included in **Research Outlook 1980** to provide a flavor of the type of joint research efforts in which ORD engages. For the most part, these efforts have recently been initiated, attesting to the fact that cooperation in the environmental research field is strong and dynamic.

National Toxicology Program

EPA has recently started substantive participation in the National Toxicology Program (NTP). The broad goal of this program is to strengthen the Department of Health, Education and Welfare's activities in the testing of chemicals of public health concern, as well as in the development and validation of new and better integrated test methods. Specific goals for the program are to:

- Broaden toxicological characterization of those chemicals being tested
- Increase the rate of chemical testing, within the limits of available resources
- Develop and begin to validate a series of protocols more appropriate for regulatory needs

At present, research under NTP is carried out for the Food and Drug Administration (FDA), the National Cancer Institute (NCI), the Center for Disease Control/National Institute for Occupational Safety and Health (CDI/NIOSH), and the National Institute of Environmental Health Sciences (NIEHS). For the FY 79 program these federal agencies dedicated a total of $41,000,000.

Development and approval of an annual plan are central to the effective planning, coordination and operation of the National Toxicology Program.

The program's annual plan includes:

- Current toxicology testing capacity (i.e., dollars, positions, and space) and how that capacity is utilized.
- Amount of test capacity that may be available in the coming year.
- Plans for test development and validation of test systems that take into account research opportunities and needs.

One of the major objectives of the NTP is to develop and validate those new or improved toxicological methods required by regulatory agencies. An additional objective is to ensure the efficient and proper toxicological evaluation of substances that may pose a threat to the public health and which, therefore, may require regulation. These substances have already been identified and prioritized by the Executive Committee, on which EPA and other chemical regulatory agencies actively participate, and several areas of research in methods development and validation considered of central importance to the research and the regulatory agencies have been specified. Thus, it is expected that major NTP objectives will begin to see immediate realization.

Through the National Toxicology Program, regulatory agencies also have the opportunity for more direct input in determining which compounds are to be selected for the NCI carcinogenesis bioassay testing program. We believe that this is extremely important since federal statutes such as the Toxic Substances Control Act (TSCA), the Federal Food, Drug and Cosmetics Act (FFDCA), the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), and the Clean

Air Act (CAA) already direct industry to perform routine testing of most compounds. The involvement of regulatory agencies in the selection process will thus help assure that the chemicals addressed by NTP are only those that are not already required by law to be tested by industry, and that the use of NTP personnel, facilities and monies is optimized.

National Center for Toxicological Research (NCTR)

For the past several years, EPA has been providing resources to the NCTR for the upgrading and expansion of their testing facilities. These sophisticated long-term testing facilities may be used for testing those chemicals for which there are likely to be no proposed test rules. Low production chemicals could be tested to increase available toxicological data, which, when appropriate, could then be applied to high production chemicals for which little data exists. NCTR will enable us to expand our chemical data base and provide services for which there are currently no facilities within the ORD.

Task Force on Environmental Cancer and Heart and Lung Disease

The Task Force on Environmental Cancer and Heart and Lung Disease, established by Public Law 95-95, provides a focal point for a concerted attack on the national problems of environmentally-related cancer, and heart and lung disease. Congress directed the Task Force to recommend comprehensive research programs that would: 1) quantify the relationship between environmental pollution and human cancer, heart and lung disease, and 2) reduce the risk and incidence of such diseases. In addition, Congress directed the Task Force to stimulate cooperation among federal agencies, coordinate all relevant research, and report annually to Congress on the progress and difficulties in reaching these objectives.

The Task Force, chaired by EPA, is composed of representatives from the National Cancer Institute; National Heart, Lung and Blood Institute; National Institute for Occupational Safety and Health; National Institute of Environmental Health Sciences; National Center for Health Statistics; Center for Disease Control; and the Food and Drug Administration. Since the Task Force's inception, ORD has actively participated on the formal Task Force, as well as on its Working Group and in project goups as well. Over this period, Task Force efforts have focused on:

- Standardization of measurements and tests
- Evaluation of the public and health professionals
- Exposure and metabolic mechanisms
- Information exchange

In 1979, the Task Force published a directory of interagency groups working in environmental health, listed data bases for federal research programs, assisted in the development of plans for the collection of environmental health data, and identified and classified the relevant funding of each member agency.

ORD participation in these efforts will continue.

Acid Rain Coordination Committee

Recognizing the potential seriousness of the acid rain problem, the President in his Second Environmental Message to Congress in August 1979 called for a minimum $10 million per year to be spent on acid rain research over the next ten years. In response, an interagency Acid Rain Coordination Committee was recently established, co-chaired by EPA and the Department of Agriculture, to plan and coordinate the overall federal research effort. ORD is currently woking closely with the other involved agencies in the development of this plan.

Interagency Committee for Stratospheric Ozone Protection (ICSOP)

The Interagency Committee for Stratospheric Ozone Protection, established under the Clean Air Act, consists of representatives of twelve federal agencies engaged in various aspects of research and monitoring related to the stratosphere, especially stratospheric ozone. The ICSOP is chaired by the EPA Assistant Administrator for Research and Development. Three ICSOP subcommittees deal with: (1) atmospheric sciences, (2) health effects, and (3) biological and ecological effects that pertain to stratospheric ozone and ultraviolet radiation. Research plans have been developed by these subcommittees and recommended to the federal government as fruitful pursuits that will fill important knowledge gaps and will improve data quality. The recommended plans will also reduce data uncertainties, thereby strengthening the scientific base that supports policy decisions. The research recommendations are currently being evaluated.

Interagency Task Force on Environmental Data and Monitoring

In his 1977 environmental message, the President called attention to deficiencies in the nation's environmental data and monitoring programs.These deficiencies included inadequate monitoring design, poor quality data assurance, poor coordination, and insufficient data and analytical information for environmental assessments, policy development and program evaluation.

To help overcome the deficiencies, the Council on Environmental Quality (CEQ) established an Interagency Task Force composed of representatives from CEQ, the Council of Economic Advisors, and the 17 federal departments or agencies responsible for environmental data and monitoring programs. EPA, with its large programs in air and water quality monitoring, was an active participant in the Task Force. The participation included preparation of an inventory of monitoring programs and a review of previously-identified issues including an analysis of the issues. A Task Force report to be released shortly calls for improved coordination and makes specific recommendations for quality assurance and data systems.

Committee on Ocean Pollution Research and Development and Monitoring

In May 1978, President Carter signed Public Law 95-273 — the National Ocean Pollution Research and Development and Monitoring Planning Act. This Act required that the Executive Branch "establish a comprehensive 5-year plan for federal ocean pollution research and development and monitoring programs in order to provide planning for, coordination of, and dissemination of information with respect to such programs within the federal government."

Specifically, this plan must include a detailed inventory of existing federal programs, an assessment and ordering of national needs and problems, and an analysis of the extent to which existing programs assist in meeting these priorities. The plan must also include recommendations for changes in the overall federal effort where deemed necessary, and a report on budget coordination efforts. The Administrator of the National Oceanic and Atmospheric Administration (NOAA) is responsible for preparing the plan, after consultation with the President's Office of Science and Technology Policy and other federal agencies involved in ocean pollution research, development, and monitoring activities.

An interagency Committee on Ocean Pollution Research, Development, and Monitoring (COPRDM), created in June 1978 by the President's Federal Coordinating Council for Science, Engineering, and Technology, was responsible for gathering and analyzing most of the information required for preparation of the first federal plan. NOAA's Deputy Administrator served as chairman of COPRDM, EPA's Assistant Administrator for Research and Development was Vice Chairman. Four working subcommittees formed by COPRDM developed specific portions of the 5-year federal plan. The subcommittees were: (1) National Needs and Problems; (2) Research and Development; (3) Monitoring; and (4) Data Collection, Storage, and Distribution. In addition to EPA involvement on these subcommittes, the Agency was also represented on the Federal Plan Task Force, established to develop the first federal plan which has its basis in the subcommittee reports.

The second federal plan is due to Congress by February 15, 1981. The interagency Committee and its newly organized staff (on which EPA is represented) are currently working to meet this mandated deadline. Over the next year, EPA and the other federal agencies on COPRDM will each develop a prospectus of their five-year plans for ocean pollution research. A series of workshops will also be held to critique the federal plan and to convey the comments to the public.

Intergovernmental Science, Engineering, and Technology Advisory Panel (ISETAP)

The Office of Science and Technology Policy (OSTP) and the Intergovernmental Science, Engineering, and Technology Advisory Panel (ISETAP) staff, with substantial assistance from the ORD, have recently issued a report that summarizes the problems of hazardous waste management and outlines the scientific and technical needs for better addressing the waste problems. In the report, ISETAP identifies hazardous waste management to be one of the highest priority problems faced by state and local governments. The report recommends what existing knowledge should be applied and what research and technology development should be undertaken over the next five years (FY 80-84) to achieve significantly more effective management of hazardous wastes.

If recommendations with near-term implications were to be implemented, according to the report, improvements in handling existing waste disposal sites — determining those which pose the greatest threats and the nature of their threat — could occur rapidly. Other report recommendations with longer-term implications include: 1) a call for improved procedures and data to define wastes and waste sites in terms of degree of hazard they pose to human health and the environment; 2) new and improved technologies for destroying or detoxifying future waste streams as well as mixtures of wastes already in "problem" sites; 3) criteria for siting new facilities; and 4) an environmental research center dedicated to hazardous waste.

In preparing this report, OSTP reviewed federal hazardous waste research activities; drew on the results of eight workshops that involved extensive participation by more than 100 scientists, engineers, and representatives of all levels of government; interviewed numerous state and local representatives and analyzed survey responses from fifty states and eight-one cities and countries; commissioned five papers; and visited several of the ORD laboratories which fund virtually all of EPA's hazardous waste research activities.

To date, the cooperation which has taken place between EPA,OSTP, and ISETAP has provided EPA researchers with unique and valuable insights into solid and hazardous waste problems and research needs, insights that are now being integrated into EPA's research efforts in this area. EPA plans to continue to seek input from OSTP and ISETAP both to structure its own research program as well as to review the products of the interagency effort.

Integrated Pest Management: Cooperation with USDA and the Interagency Task Force

ORD has been actively coordinating the Integrated Pest Management Research Program with other federal agencies since the inception of the program in 1972. That years' President's Environmental Message initiated the first major IPM research program, known as the Huffaker Project, funded by EPA, the U.S. Department of Agriculture and the National Science Foundation. This particular project has recently been completed and the major findings will soon be reported in an IPM textbook. Coordination with the USDA is continuing, however, on several other smaller IPM projects, including work on international activities.

A major new effort to improve coordination and communications with USDA is now underway. To assure that two new major EPA-initiated IPM research programs — the first a fifteen-university consortium studying apples, alfalfa, soybean, and cotton; the second a six-university consortium studying the control of mosquitos in riceland — are fully coordinated with USDA, a joint management and funding agreement has been developed with the USDA's Science and Education Administration (USDA-SEA). In the near-term, this agreement allows for the joint management and co-funding of the 15-University Four Crop IPM Consortium Project. USDA-SEA will provide $1.5M to match EPA's $1.5M for the third year of this project (FY 1981 budget). In addition, USDA will provide personnel to serve on a project overview and review team to assure that the project is fully coordinated with USDA's research, extension and education activities. A similar management team will also be established for the rice/mosquito consortium project.

Coordination of Energy Research

An important segment of the energy/environment program is carried out by agencies other than EPA:

The National Institute of Environmental Health Sciences
The National Institute of Occupational Safety and Health
The Department of Energy
The National Oceanic and Atmospheric Administration
The Tennessee Valley Authority
The National Aeronautics and Space Administration
The Department of the Interior
The Department of Agriculture
The National Bureau of Standards

Over the years, these agencies have developed a working partnership for the efficient planning and carrying out of the interagency energy program. The upshot of this effort is that today differing agencies with differing perspectives are able to work together to address a set of problems which are and will continue to be of great national significance. Each agency brings to the partnership its own special combination of facilities and experts, which, in concert, have resulted in the design of a program that encompasses the many facets of America's energy future, with interagency cooperation particularly strong in the areas of health and environmental effects.

APPENDIX C
GLOBAL ISSUES AND INTERNATIONAL COOPERATION

The Environmental Protection Agency recognizes the need to protect our nation from pollution generated by neighboring countries, as well as the need to join others in protecting the global commons. We therefore engage in a variety of international activities aimed at abating transboundary and global pollution, and at obtaining technology and expertise for the solution of domestic problems.

The Office of Research and Development often plays an important role in these endeavors. We are called upon to lend our expertise and provide technical assistance in a wide variety of cases—ranging from monitoring air and water quality to working with foreign governments to design environmental control legislation and regulations.

This international cooperation has also provided us with the opportunity to learn from others, most significantly in the area of environmental control technology development. In several countries, this technology has reached a more advanced stage than in the United States. Our expanded knowledge of these advances has helped us to avoid duplicating technology development. It has also enabled us to determine those best available technologies which truly reflect the state of the art in pollution control.

Working in cooperation with foreign nations has also provided us unique opportunities for the gathering of environmental information. For example, we are learning a great deal about acid rain from Canada and the Scandinavian countries, and our study of the unfortunate release of dioxin in Seveso, Italy continues to provide us with important epidemiological data on the effects of this highly toxic chemical.

Domestic environmental concerns have been traditionally reflected in the type and amount of research and development dedicated to international activities. Most countries cite air pollution as the most pervasive nationwide environmental problem; consequently international air quality studies receive the most resources, followed by water quality, toxic substances, and hazardous wastes. The importance placed on toxic substances control is clearly illustrated by the fact that such activity is the focal point for much research.

Globally, the U.S. research interfaces most heavily with the industrialized countries of Europe, particularly Norway, France, Germany, Sweden, the Netherlands and Great Britain. This European emphasis becomes even more pronounced when the multilateral environmental organizations of which we are a member are taken into account, as the Economic Commission for Europe (ECE), and NATO's Committee on the Challenges of Modern Society (CCMS), are essentially European communities. Our involvement with Canada and Mexico reflects our mutual need to deal with common border issues. In Asia, we have a major commitment with Japan. Our involvement with Egypt, India, Pakistan and Poland stems primarily from the availability of Special Currency Funds in those countries.

Global Issues and Research and Development Involvement

A number of environmental research and development issues are and will remain in the forefront of EPA's international research effort over the next several years. The following topics are meant to give a flavor of the many and diverse areas in which we will be involved. They do not by any means, however, represent our entire research and development international cooperative efforts.

The Long Range Transport of Acid Rain

The movement of air pollution across national boundaries is one of the most significant environmental issues being dealt with on the international level, as evidenced by the attention being given today to the environmental problems associated with acid rain. Acidity measurements and studies conducted by Scandinavian countries since 1970 have confirmed the correlation between the transport, transformation, and deposition of sulfates and nitrates and the high acidity in Swedish and Norwegian rivers and lakes. The exact sources of the emissions causing this problem have not been pinpointed; however, sources in Great Britain, West Germany, Poland and other parts of Europe have been implicated.

The acid rain phenomenon has subsequently been identified in other parts of Europe as well as in the United States. (See chapter 4, "Air.") The most significant international aspect of the problem is that, due to the long range transport of pollutants, the amount of pollution falling in one country is often determined by the pollution control policies of another. Thus, resolution of the problem requires that first all parties involved must understand the scope of the problem and the costs and benefits to each country in controlling it. Secondly, the parties must then mutually agree to develop a joint program to control sources that contribute to the problem.

To take even the first step requires both a substantial research effort to develop quantitative relationships between the emissions, their transport, and the fate of the acid rain, as well as an extensive analysis of the damages-versus-abatement costs inherent in different international solutions. To this end, we will continue to work with the ECE on the control of long range transport of air pollution and with Canada on joint studies of acid rain transport and on talks leading to air quality agreements.

Global Atmospheric Pollution

Certain substances, though relatively innocuous in isolation, pose major environmental threats as a result of their ability to modify the atmosphere. When such modification occurs, the amount or the nature of solar radiation reaching the earth's surface may be altered with ensuing highly serious effects. (See chapter 4, "Air.") Nowhere can this be more graphically illustrated than in the "greenhouse effect" theory that many have suggested will be the future result of increasing concentrations of CO_2 in the atmosphere, an increase that correlates with the expanded combustion of fossil fuels over the last century. The atmospheric concentrations of CO_2, according to the theory, may prevent sunlight which falls on the earth and is converted to infrared wavelengths from radiating back into space. This, in turn, raises the average temperature of the earth, which results in climate changes and in the possible melting of the ice-caps.

While there is sound thinking behind this theory, it is difficult, however, to prove that the events it foretells will come to pass. Currently, it is not clear what natural mechanisms may yet come into play to counteract further increases in CO_2 concentrations. It has been suggested, for example, that absorption in the ocean or increased plant growth may well keep CO_2 from reaching significantly higher levels. There are also questions about the effectiveness of atmospheric CO_2 in blocking infrared radiation. And finally, because of the complexity of the earth's weather system it is difficult to measure an average temperature of the globe; the only available data, in fact, indicating a slight cooling rather than a warming trend, possibly attributable to changes in sunspot activity or the presence of fine particulate matter in the air.

If, however, the CO_2 buildup does prove to have serious consequences, it will require major worldwide coordination of the fuel combustion process. And because it would be impractical to scrub CO_2 from exhaust gases, as is now being done with SO_2, control would necessitate drastic changes in combustion techniques. One alternative may be to switch from the use of coal, natural gas, and oil to non-hydrocarbon sources of energy such as solar power and nuclear energy.

Our international activities in this area will focus on the following:

- United Nations Environment Program (UNEP) in concert with the U.S. Climate Research Program. In particular, studies to gain a better understanding of the interactions between CO_2, climate processes, and the impact of climate variability in order to more accurately assess the consequences of possible CO_2 build-up.
- International Council of Scientific Union (ICSU) SCOPE program to examine the carbon cycle.

Stratospheric Ozone (See also chapter 4, "Air")

A related problem concerns the effects of man's activities on the ozone layer in the stratosphere. This protective layer now prevents certain potentially hazardous solar radiated ultraviolet wavelengths from reaching the earth, but were it to be reduced, a predicted increase in the incidence of human skin cancer might occur. Plant growth, ecosystems and organisms, and climate might also be adversely affected.

The major agents to impact on the ozone layer that rise from man's activities are halocarbons (notably freon) and, to a lesser extent, chemical fertilizers. In light of a recently released National Academy of Sciences report, "Stratospheric Ozone Depletion by Halocarbons," which indicates increased scientific confidence that halocarbons do reduce stratospheric ozone and a companion report, "Protection Against Depletion of Stratospheric Ozone by Chlorofluorocarbons," which indicates adverse health, ecological and climatic effects from ozone depletion, the immediate issue is that action must be taken to reduce emissions; international cooperation will be required. Our ozone activities will include participation through UNEP in the international scientific community to increase and disseminate knowledge about stratospheric ozone depletion and to make recommendations about reducing the use of halocarbons, especially as aerosol propellants.

Toxic Substances Testing and Control

The passage of the Toxic Substances Control Act (TSCA), which establishes a mandatory system for the testing and certification of chemicals, evidenced our national concern over the control of toxic substances. Because the legislation applies equally to domestic production and to imports, it is of international significance. Nations exporting chemicals and chemical goods to the U.S. must thus adhere to specific standards if their American markets are to remain open to them. As a corollary, TSCA helps guard against the export of banned toxic substances to less developed countries, which may lack the necessary regulatory protection.

Our international toxic substances testing and control research efforts will focus principally on test development, safe disposal and clean-up methods, and health effects. We will be working primarily with the following organizations and countries:

- OECD — the principal international forum for toxic substances control
- Japan and Germany (and other industrialized nations) — to compare epidemiological data
- France — to develop quick and reliable toxicity tests for screening new products
- CCMS—to study methods for handling and disposing of hazardous wastes
- International Maritime Consultative Organization (IMCO) — to regulate the incineration of toxic substances at sea
- Japan — to develop technology for dredging bottom sediments containing toxic substances
- WHO—to develop health effects criteria documents and a new chemical safety program
- UNEP — for the International Register for Potentially Toxic Chemicals
- Italy—to follow the progress of clean-up from the Seveso dioxin spill.

Marine Resources

The last few decades have seen fundamental changes in the way man uses and impacts upon the living and inanimate resources of the sea. Growing populations and increased demand coupled with advances in commercial fishing technology have led to intensified exploitation of fisheries. The continued exhaustion of land-based oil resources has resulted in the development of a major off-shore oil industry. Serious consideration is now also being given to mining the deep sea bed for manganese and other minerals. Finally, accelerated ocean transport of oil and other materials has greatly increased the frequency of harmful spills.

Beyond the problems posed in maintaining stocks of commercial fisheries, we must ensure that the yield of these fisheries remains fit for human consumption. It is known, for example, that many aquatic and marine species, such as mollusks, can accumulate and concentrate trace quantities of metals or toxic substances to levels which threaten human health. The movement of these species ignores national boundaries, making it a problem of international scope.

The exploitation of ocean resources can also raise issues that require worldwide cooperation and control. Only recently, for example, a catastrophic runaway of the Ixtocl oil well in Mexico's Bay of Campeche created an oil spill which eventually washed up on United States shores. The intensive multinational drilling in the North Sea, whose waters touch the shores of Norway, France, Denmark, Germany, the Netherlands, and the United Kingdom, also creates the potential for a severe ecological disaster with significant international ramifications. Clearly, then, such operations must be carried out in a way that minimizes the chances for such disasters.

Mining the sea bed also raises the potential for environmental damage, though it is uncertain how such damage would be manifest. One possible effect of tampering with the ocean bottom might be an alteration in the overall productivity of seas; however, much remains to be learned about the sensitivity of this ecosystem. It is also thought that the large-scale disturbance of bottom sediments might affect pelagic fish life or temperature and current patterns.

Also posing a threat of international scope is the growing ocean-going trade of petroleum and other chemicals. Large-scale accidental spills such as those recently involving the supertankers *Amoco Cadiz* and the *Argo Merchant* have significantly disrupted local ecosystems, and raised significant public concern.

Focal points for our marine research are:

- CCMS—Pilot study on management of estuarine problems using the Chesapeake Bay and determining problems associated with competing uses
- IMCO—Regulations to prevent tanker spills
- Intergovernmental Oceanographic Commission (IOC)—International exchange of oceanographic data
- Intergovernmental Council for Exploration of the Seas (ICES)—Special studies, e.g. environmental impacts of the *Amoco Cadiz* spill
- Group of Experts on the Scientific Aspects of Marine Pollution (GESAMP)—Special studies, e.g. vessel discharges of hazardous chemicals.

Environmental Data Systems

Before international action can be taken to protect the environment, it is essential that the true state of the environment be established. Consequently, a large part of our international monitoring effort will focus on the development of monitoring equipment, the design of monitoring networks, and the calibration of instruments.

The ultimate success of such an effort will depend, in part, on the compatibility of data collected from different countries; thus the techniques and instruments used to measure a given pollutant must be standard so results from different locations can be compared. Historically, this has not always been the case. For example, British methods of measuring particulates are based on opacity or particle density as compared to United States measurements based on particulate mass. This lack of standard technique has made it difficult to make mutual use of data generated in related health effect studies.

An effective monitoring network is capable of providing a true picture of pollutant problems over a wide area. The design of such networks will be a future cooperative international research and development effort, and will work toward improving the present distorted worldwide pollution picture brought about by the clustering of monitoring stations near urban concentrations and in but a few countries.

A related problem involves finding locations where baseline measurements can be taken to establish the natural background levels of pollutants. Such levels reflect only those pollutants generated through natural processes such as photosynthesis or volcanic eruptions. It is, however, difficult to find places uncontaminated by man-made pollutants, and many such measurements are now being made at mid-ocean, or in the remote interiors of continental land masses.

Future cooperation will involve:

- CCMS—A pilot study led by France on the remote sensing of marine pollution
- UNEP—Participation in the Global Environmental Monitoring System (GEMS) which aims for the establishment of at least one major monitoring

station per country (through collaboration with WHO and WMO)

- Federal Republic of Germany—Establishment of standard biological material specimens for experiments measuring the accumulation of pollutants.

Desertification and Deforestation

Desertification is the process by which, usually through man's activities, fertile land loses its ability to support plant and animal life.

A classic example of desertification is now taking place in the Sahel, the southern fringe of the Sahara desert, where recent drought has combined with overgrazing to destroy the ground cover necessary to keep soil in place. Topsoil is thus being blown away and is gradually being replaced by sand. Similar desertification took place in the American Midwest during the 1930's, when drought combined with intensive and inappropriate agriculture to produce the Dust Bowl.

The problem of desertification is particularly prevalent in developing countries. Here, medical advances have resulted in explosive population growth; at the same time, old farming methods, which were in harmony with the land, are giving way to more aggressive forms of agriculture to feed this population. The result is a vicious cycle where inhabitants are overusing land to provide sustenance for more mouths, yet while doing so, losing more and more of this land to desertification.

Deforestation is a quite similar phenomenon, occurring when man overtaxes the forests for fuel and wood, and for grazing for animals. Subsequent loss of land cover increases erosion which, in turn, reduces the ability of the land to retain moisture during dry spells.

With proper techniques, desertification and deforestation can be controlled or even reversed. More needs to be known, however, about the ways that ecosystems sustain themselves, and better techniques for forecasting variations in these ecosystems must be developed.

Our efforts will focus on the following:

- Egypt—Development and verification of the computer model SAMDENE, which predicts the effect of climatic variables on desert growth
- Mexico—Methods to abate the increasing salinity of the Colorado River (caused by irrigation and other withdrawals in the United States) as it flows across the border
- CCMS—Pilot study led by France to improve our hydrological forecasting capabilities.

Radioactive Waste Management

As more nations turn to nuclear power as an energy source, the issue of the safe disposal of nuclear wastes will become increasingly important. This is a multi-faceted issue that involves both the management of spent nuclear fuel and the disposal of high- or low-level wastes. A significant corollary to the radioactive waste problem is that since some nuclear material from the wastes could be used in weapons, secure and cost-effective management alternatives could well lessen the likelihood of the unauthorized proliferation of such weapons.

At present, there is a steadily growing accumulation of spent fuel at operating nuclear power plants. In the very near future, the amount of this spent fuel will exceed the storage space available at reactors. It will then be necessary to either move it offsite to reprocessing plants, to find interim storage, or to see to its ultimate disposal. Each of these options involves that major precautions be taken to protect the environment.

The proper handling of high- or low-level wastes is also vital to protecting the environment. These radioactive by-products of nuclear power generation are classified depending primarily on the intensity of their radiation levels. High-level waste, although very small in physical volume, requires heavy shielding and remote handling. It must be kept in isolation for thousands of years before its radioactivity decays to ambient levels. While there are currently several disposal options available that make use of stable geological structures, the option selected in the United States, however, must also satisfy specific environmental criteria now under development.

This problem of high-level waste is international in scope. Suitable geological structures for disposal may exist only in a few places around the globe. Countries possessing only one or two reactors may find it uneconomical to develop their own natural disposal facilities. Finally, the improper disposal of nuclear wastes in one country could result in the spread of radioactivity to other countries.

Low-level nuclear waste consists of material slightly contaminated with radioactivity. Compared to high-level waste it can be handled with a minimum of special equipment and shielding. However, precautions must be taken to keep this material from entering biological pathways where it could be reconcentrated to hazardous levels. In the past, low-level wastes in the United States have been disposed of at commercially-operated landfills. The performance at these landfills has generally not been satisfactory, however, and has led to the new regulations currently being formulated by the Nuclear Regulatory Commission, with EPA assistance.

While the land disposal of low-level waste is the most common practice, a number of European countries also dump nuclear waste into the Atlantic Ocean. This is done under the surveillance of the Nuclear Energy Agency and OECD and is permissible under current treaties. The ocean dumping of high-level waste, however, is prohibited.

It is anticipated that, as low-level waste quantities increase filling suitable land sites, more countries will turn to ocean dumping. While this form of disposal is also a future option for the United States, the integrity of the environment would be protected under the regulations of EPA's ocean dumping permit program.

In the future we will continue our involvement in the following international efforts currently underway to deal with nuclear waste issues:

- International Nuclear Fuel Cycle Evaluation (INFCE) group, an interagency task force under the leadership of the State Department, that works with more than thirty countries—to find an international solution to the interim spent fuel storage problem
- OECD (with the Nuclear Energy Agency) — to develop a set of policy recommendations for high-level waste disposal, including legal, financial, and administrative aspects
- Nuclear Energy Agency — to establish appropriate standards for packaging and monitoring low-level wastes, as well as defining suitable ocean sites
- International Atomic Energy Agency — to develop standards and criteria for various radionuclides.

Development and Environmental Planning

Perhaps the most pervasive problem underlying the implementation of international environmental programs is the reconciliation of such programs with the specific national and international needs and development plans of individual nations. Still, no country operates in an environmental vacuum. Whether it be protection of endangered species, prudent use of marine resources, or control of pollutant discharges into the global commons, the environmental actions of one country inevitably mesh with those of others.

So too do economic actions. Over the last decade, currency crises, oil embargoes, and food shortages have all served to demonstrate the increasing economic interdependence of nations. While the industrialized nations seek to adjust to these new patterns of trade and economic growth, the less developed countries are becoming more aggressive in trying to raise their standards of living. Further complicating the situation is the emergence of several new categories of nations — OPEC countries, medium developed countries such as Brazil, and fourth world countries, such as Bangladesh — each with unique national problems and objectives. It is impossible, however, to separate these national problems from the state of the international physical environment.

In the fourth world, for example, the fundamental problem is one of sheer survival. Here, overpopulation in lands of marginal productivity has already created severe cases of soil exhaustion, desertification, and deforestation. Thus, with few or no resources to trade for the necessities of life, these countries must develop plans to both conserve existing land, water, and fuel and cope with adverse demographics. In some cases, these plans may involve technological fixes, but in others, reaching national goals may require large-scale resettlement and societal change. In doing so, a significant threat to the environment is posed.

Far more fortunate are the OPEC nations, notably the Arab states, that have sufficient incomes to deal with the needs of their populations, even where the land is not particularly fruitful. Their national development plans reflect this wealth. However, these countries are also tempted by heroic engineering projects to meet their needs, such as towing icebergs from Antarctica for water, which may have profound environmental implications. Required here as an adjunct to development plans are integrated technology assessments to determine those projects that represent only the wisest financial and environmental investments.

Traditional third world countries such as India are also planning for their national economic futures. In the past, it has been assumed that these nations would attempt to parallel the pattern of economic development set by the Western industrialized countries. Today, however, this path is being questioned as the changes in social structure and capital and labor distributions necessary to accomplish this objective are now being more carefully considered. There has even been some recent question as to whether the traditional western pattern of development is entirely desirable even in the industrialized countries. In any event, to make the rational decisions they must, these third world countries require national planning models capable of predicting the economic, social, and environmental costs and benefits offered by a variety of development scenarios.

Circumstances will inevitably lead different countries to seek different kinds of planning tools. What is ultimately required on the broad scale, however, are highly flexible models capable of working on the local project level as well as on national and international development scenarios. In addition, means to incorporate environmental concerns into decision-making processes resulting in regulation and control must be found. In the United States, this is being accomplished at the federal level by means of the environmental impact statement and through EPA or state agency enforced environmental standards. Other approaches, however, are also possible. The Polluter Pays Principle approach, adopted by the OECD, for example, employs economics as the method to shift decisions in the direction of environmentally favorable alternatives. Other techniques involve mediation or arbitration.

The methods of regulation and control adopted by each country will reflect the individual circumstances of each nation. It is expected that the relative importance given local versus national decision-making bodies will also vary widely. Strongly centralized countries, such as France, will most probably impose national standards, while countries such as Germany, where power is tilted toward the states, will tend towards local action. Different legal traditions and economic structures will also affect the nature of decision-making.

We will continue to work with the following groups to help ensure that each country's process is compatible:

- UNEP and ECE — to develop overall policies and guidelines
- OECD—to develop statistical indicators of environmental quality to complement economic statistics
- Bilaterals—to develop standard methods for assessing environmental impacts.

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